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CHARLES DOOLITTLE WALCOTT

PALEONTOLOGIST—1850–1927

CHARLES DOOLITTLE WALCOTT, of Shropshire and New England ancestry, was born on March 31, 1850, at New York Mills, New York, and died of apoplexy at Washington, D. C., on February 9, 1927. Standing about six feet two inches in height, slight, but of athletic build, he had a commanding presence that attested a magnificent physique. Confident, quick of decision, with a matter-of-fact face, Walcott suggested the administrator rather than the savant, and yet he "achieved in scientific circles an exalted position attained by few."

Walcott's first paper, on a new species of trilobite, appeared in 1875, and his last one, on the Cambrian, two months after his death. His strictly paleontological and geological bibliography appears to have over 170 titles, and of these about 110 have to do with the Cambrian. The list of his complete writings will rise into the hundreds.

Walcott's education was that of the local public schools, and then of the academy at Utica, an institution in which other leading geologists received their first lessons in science. As a paleontologist and geologist, however, he was virtually self-educated, first by direct contact with nature, and then from books and colleagues. In 1868 he left the academy and during the following two years was a clerk in shops. In 1871, at Indianapolis, he met the state geologist, Professor E. T. Cox, who restimulated him to take up the study of paleontology, which had been dear to him ever since his fourteenth year, when he found his first fossil. The actual meaning of fossils, however, came to him through meeting in 1864 Colonel E. Jewett, one of New York's earliest paleontologists, who advised him and helped him to obtain books.

Following Cox's advice, Walcott took up residence in 1871 on a farm near the picturesque and highly fossiliferous region of Trenton Falls, which is about 15 miles to the northeast of his birthplace, and between times he collected the fossils turned up by the plow and quarried for others. In the course of two years he had amassed a large collection of Trenton specimens that was wonderfully rich in trilobites. This collection he sold in September, 1873, to Louis Agassiz, and now he came directly under the magnetic influence of that great man. Among the trilobites, there was a specimen of *Isotelus platycephalus* that showed, even if imperfectly, some of the ventral

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limbs—a discovery made for the first time, but one that only an Agassiz could properly evaluate. Agassiz therefore urged Walcott to search particularly for trilobites preserving the ventral anatomy, and the very next year the latter found his paradise. Quarrying in it, he had at the close of 1876 no fewer than "3,500 entire trilobites; 2,200 were in condition to warrant sections being made of them." This second collection also went to Agassiz.

Walcott's career as a paleontologist now lay straight before him, and with Agassiz' endorsement he became in 1876 assistant to the greatest American paleontologist of the time, James Hall. That summer Hall sent him to Waldron, Indiana, to open a quarry for Silurian fossils, and by the end of the season he had shipped to Albany two tons of fossils and rock, much to the delight of Hall, who never could get enough fossils! Then in 1878, Walcott found, near Saratoga, New York, "primordial fossils" in place; he tells us late in life that he had seen some of these in a drift block near his home when he was only seventeen, and had ever after been on the hunt for the strata from which the slab had come. He naturally wanted to describe these things—one of the dreams of his youth—but Hall was reluctant, and further, seeing the restless ambition of the young man, and his marked capacity for accomplishment, recommended him to Clarence King, the director of the United States Geological Survey. Finally, however, Hall yielded to Walcott's desire to describe the few species found near Saratoga, and published his results in 1879. This was Walcott's first paper on the Cambrian faunas, of which he was to become the great revealer.

In this same year King appointed Walcott assistant geologist, and shortly afterward the whole of the Cambrian of the country was open to his investigation. First came the wide expanse of the Far West, with its wonderful clear atmosphere and its stratigraphy everywhere unobscured. Soon Walcott was overrunning Utah and Nevada, and finally the generalizing Powell took him in 1882 into the depths of the Grand Canyon of the Colorado. Here it turned out that there were not only "primordial fossils," but, even more surprising, 12,000 feet of still older rocks; unfortunately, however, these latter had but few fossils. This older series was for some years included by all in the Paleozoic, but before long was seen to be of another world, the Algonkian era of Powell.

The stratigraphic problems of the Cambrian and the "primordial faunas" of his native state, however, kept beckoning Walcott, especially the extremely difficult "Taconic question," a problem that had vexed all geologists attempting its solution, had thrown its originator, Emmons, forever into the limbo of the improbable, and had been watched over by the eagle eyes of James Hall, James D. Dana, T. Sterry Hunt and Jules Marcou. Walcott apparently never asked, "Can I solve this riddle?" but, Siegfried-like, boldly entered the arena, and, while it can not be said that he completely unravelled the stratigraphic sequence and not at all the structural conditions, he did lay down the ground plan, and, especially by revealing the many local faunas that he found from place to place, made it possible for Arthur Keith to show that most of the structural difficulties of the Taconics are due to the highly imbricated or overthrusted nature of the area extending from the Highlands of New York into Vermont and far beyond to Gaspé.

In 1888, Walcott was placed in charge of all invertebrate fossils in the Geological Survey, and there followed a flood of important papers on the Cambrian of eastern North America. During the summer of 1890, he was in Albany and called on Hall, who, as usual, had a tale of woe to tell about the probable lack of state appropriations for the Survey, which would in all likelihood make it impossible for him to provide a salary for the writer, who was at that time his private assistant. Walcott told me of what Hall had said, and assured me that in case of trouble he would make provision for me on the United States Geological Survey. Again as usual, however, nothing awful happened at Albany, and I did not get to be Walcott's assistant until the spring of 1893.

Walcott succeeded Major Powell as director of the Survey in 1894, holding that office until 1907. He thus inherited the Survey the year after the great cut in its annual appropriations from Congress, when they were reduced one half. Here was a great task ahead, and he worked at it so heroically that in a few years he had regained the lost ground, maintaining, at the same time, the high ideals of the Powell Survey. With this increased burden of administrative work, the detail of his beloved Cambrian problems had to be assigned to assistants, although each summer found Walcott in the field collecting new stratigraphic and faunal data. In the meantime, he not only built up and made larger than ever before the appropriations and publications of the Survey, but also developed the Reclamation Service, initiated the Forest Service and the National Advisory Committee on Aeronautics, and helped along in Congress the appropriations for the United States National Museum.

Even this is not all, for in 1901 Walcott was one of a small committee that went to Andrew Carnegie and appealed to him to make possible the wish of the Father of our Country to have at Washington a national university. The outcome of this appeal was

the founding of that great institute of research, the Carnegie Institution of Washington, of which Walcott was the first secretary (1902–1905).

It has been the history of the Smithsonian Institution that the office of secretary alternates between workers in the physical and the natural sciences. Secretary Langley, as astronomer and physicist, had followed Secretary Baird, a zoologist, and as the former was but little familiar with the ways of Congress, Walcott helped him greatly with his appropriations for the various bureaus under the fostering care of the Smithsonian. Upon the death of Langley, this helpfulness on the part of Walcott naturally brought him favorably into the minds of the regents, and as the appointee was expected to be a naturalist, Walcott was chosen in 1907 to be secretary and executive head of the Smithsonian. This appointment is considered the greatest honor that can come to an American man of science.

The executive duties of the secretary of the Smithsonian Institution need not take up all of his time, and so we find Walcott again working with his vast riches of Cambrian facts and fossils. Moreover, he could now widen out still more the field of his researches, and almost every summer since 1907 he and his family have devoted themselves to unearthing the wonderful Cambrian succession in the Rocky Mountains of Canada. Here the Cambrian is extraordinarily complete, with a thickness of more than 12,000 feet, and an unparalleled abundance of fossils. Walcott also had the Carnegie Institution send an expedition to China, headed by Bailey Willis, to collect fossils, and later on sent J. P. Iddings to make additional Cambrian collections. He likewise persuaded local collectors in many lands to send him Cambrian material and borrowed that of the Geological Survey of India. Truly, Walcott assembled in the Smithsonian more Cambrian fossils than there are in the museums of all the rest of the world!

One of the most striking of Walcott's faunal discoveries came at the end of the field season of 1909. As his party was coming down Mount Wapta, Mrs. Walcott's horse slipped and in so doing turned up a slab that at once attracted her husband's attention. Here was great treasure—wholly strange crustaceans of Middle Cambrian time—but where on the mountain had it come from? Snow was falling and the search for the original layer had to be left to another season. Next year Walcott was back again on the southwest slope of Wapta and eventually the layer from which the slab of the previous year had come was discovered—a bed of black shale, later known as the Burgess shale, 3,000 feet above Field, British Columbia, and 8,000 feet above the sea. A stone quarry in this shale, opened and operated during the summers of 1910 to 1913, and again in 1917, yielded what is probably the strangest and most interesting of all invertebrate assemblages: algæ, many sponges with spicules, an array of annelids showing internal anatomy, brachiopods, and, most numerous of all, phyllocarids and trilobites with appendages and internal structures. Walcott has described 70 genera and 130 species of the Burgess forms, but a vast mine of knowledge still lies buried in these most difficult of fossils.

Of Walcott's striking papers, other than those already mentioned, a few more must be singled out. Among his early contributions to attract wide attention was his vice-presidential address before the American Association for the Advancement of Science in 1893, entitled "Geologic Time, as indicated by the Sedimentary Rocks of North America." Here he opens with the significant remark: "Of all subjects of speculative geology few are more attractive or more uncertain in positive results than geologic time." After a careful analysis of the known facts, he concludes that "geologic time is of great but not of indefinite duration. I believe that it can be measured by tens of millions, but not by single millions or hundreds of millions of years." This was, of course, before radium disintegration was known.

Among Walcott's many papers on trilobites, the most striking one goes back to 1881—"The Trilobite; New and Old Evidence relating to its Organization"—and has to do mainly with his original discovery of the anatomy and the legs of trilobites. Nothing that Walcott did afterward brought him more fame, and coming so young in his life, it aroused expectations of other big results, which followed quickly, one after another. Of his later contributions, the best one dealing with the morphology, growth stages, and phylogeny of trilobites, has the title "*Olenellus* and other Genera of the Mesonacidæ," 1910. It treats of 36 species in 10 genera of these most specialized of all Cambrian trilobites.

Of faunal studies, the most comprehensive one is "The Fauna of the Lower Cambrian or *Olenellus* Zone," 1890, which remains the classic of the subject; it treats of 138 species, but a revision of what Walcott has at Washington will bring the total to several hundred. His most monumental work is, of course, the two-volume "Cambrian Brachiopoda," 1912, which brings together the world's known forms, totalling 535 species in 59 genera, of which 360 occur in North America. This is another classic, the foundation upon which all classification of the Brachiopoda must rest.

At the memorial meeting in Washington on February 10, Walcott's colleagues and associates said: "During the forty or more years of his life in Wash-

ington, he displayed to a degree that excited our greatest admiration a capacity for the dual duties of research and administration." As one of the world's leading paleontologists and revealer of Primordial Faunas, he outshone by far even the illustrious Barrande of Bohemia, and in this country he was one of the outstanding men of all science, evidenced by his presidency of the National Academy of Sciences from 1917 to 1923. Five medals (Bigsby and Wollaston of England, Gaudry of France, Thompson and Hayden of this country), and honorary degrees from Cambridge, St. Andrews, Christiania, Paris, Hamilton, Chicago, Hopkins, Pennsylvania, Yale, Harvard, and Pittsburgh further testify to the high place he held at the seats of learning in America and Europe.

CHARLES SCHUCHERT

NEW LIGHTS ON EVOLUTION[1]

I

THE past two decades or more seem to have been marked by too great a confidence in the experimental method as a universal solvent of biological problems. It would be as unreasonable to expect the physicist alone to be able to unriddle the mysteries of inanimate nature, without any aid from the fundamental science of chemistry, as to assume that the much more complex problems of living matter can be resolved by the investigation of functions and activities alone. Living beings are so much more a product of their past history than of present environment that the historical and comparative study of animate matter will always be of fundamental importance. For the moment many biologists have lost their sense of proportion and have over-emphasized the experimental side with a consequent sterility and loss of interest in the science. Biology from its very nature will apparently always be more a historical and comparative science than an experimental one. For its normal development the experimental and structural study of organisms should obviously go hand in hand.

One of the most interesting tendencies of the present time is the vivid revival of the interest in biology. We are accustomed to regard the epoch, which began with the appearance of the "Origin of Species," as marked at the outset with misunderstanding and lack of interest. It is worth while accordingly to remark that the first edition of fifteen hundred copies of Charles Darwin's immortal volume, published as you will remember in 1859, was exhausted at the time of issue and that within less than a year three other editions, comprising thousands of copies, were called for.

[1] Public lecture delivered under the auspices of the Royal Canadian Institute and the University of Toronto.

I may remind you that the full title of Darwin's great book is the "Origin of Species by Natural Selection." The severest criticisms of the work as a matter of fact have been based on its author's supposed opinion that natural selection alone is able to account for the origin of species. In one of his chapters, however, Darwin states that it is the internal factor of variability which is of the greatest importance in connection with the origin of the species. The only reason that he did not deal at greater length with the subject of variability in living organisms was the complete ignorance, then and since on the part of biologists, as to the cause of variability. In another of his chapters Darwin makes the illuminating and indeed, in the light of very recent events, prophetic statement, that the greatest degree of variability is found in the larger groups of plants and animals. Within the limits deliberately set by himself, Darwin produced a book which will always rank as the greatest classic of the biological sciences.

We may now turn to the question of the present position of the problem of the origin of species, and in this connection we can not do better than refer to some of the recent utterances of the Nestor of American evolutionary biologists, Professor Henry Fairfield Osborn, director of the American Museum of Natural History. In a series of essays devoted to the theme of the teaching of evolution (Charles Scribner's Sons, New York, 1926), he remarks on page 29: "In my opinion natural selection is the only cause of evolution which has thus far been discovered, and demonstrated."

In his recent Oxford address on evolution, delivered on the occasion of the meeting last summer of the British Association for the Advancement of Science, in that venerable university, Osborn points out that as the result of the manifold activities of naturalists in more recent years we are now in the position to state the conditions under which new species make their appearance although not their cause. The most important element from the naturalist's standpoint is apparently isolation such as is found in islands of the sea or in the case of fresh water forms in rivers once connected but now separated by geological change. Such species are in general distinguished by the fact that they do not intergrade with their more nearly related species. His general conclusion is that: "We know the *modes* by which subspecies and species originate; in fact, there is little more on this point to be known. But this very knowledge renders the problem of *causes* infinitely more difficult than it appeared to Darwin."

The question of the origin of species is in fact much too large a one to be attacked successfully by any one line of biological investigation. Of late

years it is the geneticists who have expressed themselves with the greatest confidence and positiveness on the subject of the origin of species. Of these perhaps the most judicial is William Bateson, whose recent untimely death we all deplore. Although earlier he shared the confidence, characteristic of his group, his latest view was that we know nothing whatever about the origin of species. Naturally enough such pessimistic utterances, which are not confined to the author just cited, have been seized upon by the so-called fundamentalists, as showing that biologists have in reality no knowledge of the basal problem of their science. A consideration of the full significance of recent discoveries in biology, particularly in the case of plants, seems however to lend little support to a position of pessimism or negation. On the contrary, these recent investigations have tended to show that many hitherto unexplained phenomena are accounted for by the factor of hybridization.

An illuminating feature of the Darwinian method was the comparing of plants and animals in nature with those under cultivation and domestication. He pointed out that the best cows and the best cabbages are both the result of deliberate and continued selection of the part of man, in other words, are the consequence of what Darwin called artificial selection. Similarly he made it clear that in the long course of geological time those plants and animals best suited to their natural environment survived. To this natural weeding process he applied the apt title of natural selection. The possibility of selection whether natural or artificial depends on the inherent variability of living organisms, as was long ago pointed out by Darwin himself. The cause of variability is now apparently well in sight as the result of recent comprehensive investigations on the minute structure of important cellular elements in plants and animals. It has long been known on the plant side that the crossing of different natural species led to the production of offspring of infinite variability. Although this situation has for years been a commonplace among the producers of new varieties of cultivated plants, the matter has not until recently been followed backwards to the minute but highly important details of the reproductive cells. The biologist of late has been paralleling the path of the chemist in attempting to resolve his problems by reference to minute ultimate structures. Naturally he can deal with only the smallest units of structure clearly recognizable by the microscope, particularly those entering into the organization of the nucleus of the cell.

When two species are crossed, the result is a hybrid. The sterility of hybrids has been long and even popularly known, as witness the cases of the mule and the mulatto. Recognized hybrids among animals are relatively rare, but among plants the occurrence of hybrids both natural and artificial has become a commonplace. The structural peculiarities of the most minute elements of the reproductive cells of hybrids present a subject of fundamental interest and importance which has only recently received the attention which its significance demands. I have been occupied for many years in this fruitful field and have reached conclusions, the general tenor of which I shall try to summarize for you to-night; namely, that hybridization offers an explanation for variability and that variability accounts for the origin of new species.

Some twenty years or more ago a Swedish botanist, Rosenberg, gave the first clear description of the nuclear peculiarities of reproduction in hybrids. He noted that in a natural hybrid between two species of sundew, namely, *Drosera rotundifolia* and *D. longifolia,* the reproductive cells presented very interesting conditions in their divisions. In the species *D. rotundifolia* when the mother cells, which produce the four pollen grains characteristic of the genus Drosera, undergo their first division, the nuclear substance appears in the form of ten so-called chromosomes. In *D. longifolia,* on the other hand, there are twenty chromosomes under the same conditions. In the hybrid between the two species, the number of chromosomes in the body cells is the sum of ten and twenty, namely, thirty. In the division of the mother cells of the pollen grains of the hybrid, however, a very interesting condition presents itself. There are present ten *double* chromosomes and ten *single* ones. The doubles are called bivalents and the singles univalents. The double chromosomes are regarded by Rosenberg as consisting of pairs derived one from each of the two parents. The ten singles on the other hand represent the remainder of the chromosomes of *D. longifolia,* which have failed to find mates. Equally interesting is the behavior of the chromosomes in division. In the somatic cells the conduct of the chromosomes is quite normal, but in the reproductive division the univalent or single chromosomes lag and are frequently left out when the two nuclei, formed after division, are completed. The laggards frequently form one or more additional and smaller nuclei. While the parent species produce their pollen grains in the normal number of four, the hybrid has more than four pollen grains produced by each mother cell. Further, the pollen of the hybrid is largely sterile. It is thus clear that the hybrid Drosera differs from both its parents in a number of well-marked features. Although the first observations in this important field were made on the natural hybrid described above, subsequently similar phenomena have been observed in numerous artificially pro-

duced hybrid plants. We have thus arrived at clear criteria for hybridism based on the study of the cytological changes in the dividing mother cells of the reproductive elements. It is an interesting fact that these abnormalities are not found in the vegetative or somatic divisions. This no doubt is the reason that their importance in the study of the origin of species has received so late a recognition.

Rosenberg quickly noted that similar peculiarities appeared in the reproductive divisions of the very variable dog-rose of Europe, Rosa canina, and one of his students, Taeckholm, carried out observations on European roses in general with similar results. Simultaneously Blackburn and Harrison made parallel observations on the roses of England. Abnormal reproductive divisions in the roses of Europe, western Asia and northern Africa, united with a large degree of variability and likewise marked sterility, make it more than probable that the multiplication of species of roses in the European area is the result of hybridism. Our eastern American roses are of pure race, but in America another huge and variable rosaceous genus, Crataegus, the hawthorns, has been shown by investigations carried on by Dr. A. E. Longley to be largely of hybrid origin. Hybridism in fact is extremely common in the larger genera of the Rosaceae. Not only have the criteria of hybridism (sterility and abnormality in the reproductive divisions) been clearly discerned in many of the Rosaceae, but although the field is as yet new and comparatively unworked, numerous examples have already presented themselves in the Compositae, Myrtaceae, Betulaceae, Fagaceae, Proteaceae, Gramineae, etc., etc. We are in fact already in the position to state with confidence that hybridism has played a large rôle in the multiplication of species among the higher and even the lower plants.

We may at this stage consider, so far as plants are concerned at any rate, the cause of the high variability, noted by Darwin, as an outstanding feature of larger groups. It receives its natural explanation as the result of hybridization in nature, since precisely in these very large groups we find sterility, abnormalities in reproductive divisions and in the production of pollen. Further the conclusion recently set forth by Osborn and cited in an earlier paragraph, that isolated species are constant and not connected by intermediates with other isolated species, is attributable to the absence of the possibility of hybridization. On the other hand, where species grow in proximity, they may naturally be connected with every possible sort of hybrid intergradation.

ANIMALS

We may now turn our attention to the animal side. Here known hybrids are infinitely less common than is the case with plants. I have chosen the Orthoptera for investigation in this respect. This group is particularly favorable by reason not only of its great extent but also on account of the large size of the reproductive cells, which make them suitable for cytological study. The grasshoppers and locusts belonging to this group are distinguished for their numerous and extremely variable species. It is in fact said that there are as many as thirty thousand species of grasshoppers in the larger sense in North America, and hundreds of new species are described every year. In the reproduction of animals the sperms are produced in fours precisely as are the corresponding pollen grains on the plant side. If one examines microscopically the reproductive gland or testis of almost any grasshopper, locust or cricket, one usually finds present huge quantities of sterile sperms, particularly in the earlier stages of activity of the gland. These abortive sperms naturally suggest a comparison with the correspondingly sterile pollen of the hybrid Drosera and that of numerous species of roses, hawthorns, etc., etc. The earlier formed sperms present the same abnormalities as present themselves in the divisions of hybrid plants. It is at once reasonable and scientific to suppose that the huge multiplication of species in certain Orthoptera is like the similar multiplication of species in large groups of plants, due to hybridism. The peculiarities in relation to sterility and abnormal conduct of the chromosomes in the reproductive divisions are not confined to the Orthoptera, but have been unwittingly described in large and variable genera of snails, butterflies, moths, spiders, flies (Diptera), etc. I assume accordingly that the variability found in the large groups of animals, since it is accompanied by the same cytological abnormalities and the same sterility as is found in known and suspected hybrid plants, is likewise an indication of the rôle played by hybridism in the formation of new species. Hybridization appears also to be responsible for the phenomenon known as parthenogenesis.

II

PARTHENOGENESIS

An interesting abnormality in reproduction is presented by many plants and animals. Normally the formation of offspring depends on the fertilization of the egg of the female by the sperm of the male. In a number of cases, however, eggs are able to produce new individuals without previous fertilization. This phenomenon is known as parthenogenesis. It is well illustrated among plants by the common dandelion. In this species, the pollen grains are for the most part abortive and even where they reach a certain size lack the two nuclei which are present in

normal pollen grains of other flowering plants. It is possible to remove entirely the anthers or pollen-producing organs in the young flower by excision with a sharp razor, and with them the stigmata or receptive surfaces connected with the ovaries. The flowers under these circumstances set seed precisely as if nothing had happened. My observations on the pollen mother cells reveal the fact that their divisions show all the cytological peculiarities of hybrids. There are, for example, both bivalent and univalent chromosomes, which lag after the hybrid manner in division. Further the lagging of the chromosomes is responsible for the formation of small and supernumerary nuclei, which give rise to small abortive pollen grains. Finally, the pollen as a whole is completely sterile and consequently incapable of effecting fertilization. Similar observations have been made on the cudweeds (Antennaria), the hawkweeds (Hieracium), the ladymantles (Alchemilla), etc., etc. I have observed an interesting case in the common broomrape, a parasite, known as *Orobanche uniflora*, which is at the same time parthenogenetic and presents all the peculiarities of known hybrids. On the basis of detailed agreement in essential features with known hybrids, there seems to be no reasonable doubt that parthenogenesis in plants may be a favorable variation following previous hybridization. This view has been ably put forward by Ernst before the cytological peculiarities of hybrids were as clearly formulated and understood as they are at the present time. Winkler's criticisms, which represent the narrowness of view which so often characterizes the pure experimentalist, are accordingly of slight importance.

The cytological evidence seems clearly to indicate that parthenogenesis is the result of previous hybridization in plants and it is of interest in the present connection to discover if the evidence points towards a similar conclusion in animals. One of the most striking cases of parthenogenesis is presented by the green-flies or aphids as well as related parasitic insects. My own studies show here the same peculiarities as in parthenogenetic and hybrid plants. There are univalent lagging chromosomes, which often form supernumerary nuclei and a very large amount of sterility is presented by the sperms, which are frequently highly abnormal. The univalent laggards have been noted by the zoologists, but under a misapprehension as to their significance have been called "sex chromosomes." It is, however, in view of the whole situation, quite impossible to put this interpretation upon them. The described cytological conditions in connection with parthenogenesis in ants, bees and wasps, lead to the conclusion that these too, so far as they are parthenogenetic, are of hybrid origin. A similar statement holds for parthenogenesis in certain parasitic worms.

An interesting case is presented by the grouse-locust, Apotettix Eurycephalus, in which Nabours has recently described parthenogenesis. On request he has kindly furnished me with suitable material and I have been able to observe not only a high degree of lagging in the chromosomes, but also a marked degree of sterility. It is of interest in this connection to note that Harrison had already suggested on the basis of Nabours's work that the species under consideration is of hybrid origin.

MUTATION

A great deal of attention has been focussed in recent years on the so-called phenomenon of mutation or saltatory origin of species. Stock illustrations of this condition are the evening primrose (Oenothera), *Drosophila melanogaster* and the Boston fern. There is little doubt both from the experimental and morphological standpoints that most of the species of Oenothera are of hybrid origin. Their extreme variability in many instances, their usually high degree of sterility and the cytological peculiarities, particularly of the more sterile species or subspecies, clearly testify to a heterozygous origin. The Boston fern, which originated some time ago in a greenhouse in Cambridge, has been investigated in my laboratory and it shows both the extreme sterility and the special cytological characteristics of a hybrid. Elsewhere the present author has shown that *Drosophila melanogaster* is, on the basis of its extreme variability and its cytological abnormalities, of hybrid origin.

There can scarcely be any reasonable doubt that so-called mutation in general is associated with previous hybridization. The so-called mutating forms present usually the high variability, the sterility and the cytological peculiarities of known hybrids. Further, Tower's experimentally produced hybrids of the potato-beetle are described by him as showing subsequent mutations.

GENERAL CONCLUSIONS

It will be obvious to the reader who has followed the data and descriptions of the preceding paragraphs that striking abnormalities are frequently found in the divisions of the reproductive cells of both plants and animals, where these are highly variable or belong to large groups or genera. These peculiarities present an inescapable resemblance to the conditions found in known hybrids. It follows that the high degree of variability noted long ago by Darwin, in large groups of plants and animals,

has its natural explanation as the result of hybridization.

It seems clear that the phenomenon of parthenogenesis in plants and animals is likewise to be explained as a successful result of previous hybridization. Since the general sequel of hybridization is sterility, the only outlook for the offspring of a hybrid union is either the development of improved sexual fertility or the appearance of parthenogenesis.

The peculiarities of so-called mutating forms find their rational elucidation in the study of the phenomena, variational and cytological, of known hybrids. It accordingly follows that mutation, so far as it is a real cause of the origin of species, is merely the appearance of more or less constant offspring, following a previous hybrid union.

In our study of the origin of species we have now apparently, after many years of comparatively ineffectual effort, reached a point of view which will enable us to explain some at least of the fundamental causes of variation, fluctuating or fixed. One-sided attack has been shown to be futile. The great merit of Darwin's work is its many-sidedness. To-day, too, it seems clear that for permanently valid results in biology, structural and experimental work must go hand in hand. Moreover, observations in the field and observations in the laboratory must supplement one another for the most fruitful results.

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SCIENCE AS CULTURE

ONLY about ten per cent. of the undergraduates who, since the war, have taken general chemistry at ten leading colleges and universities[1] pursue further chemical courses. But one student in forty-five does postgraduate work in chemistry.

It would require an exhaustive study of registrar's records and post-collegiate careers to determine how many graduates make any direct or indirect use of chemistry in their life work; but this is not necessary to confirm the common observation that they would be only a small fraction of those who take an introductory course in the science.

What, then, should be the purpose of such a course?

"To state the laws and define the conceptions of the science in terms of experimental facts"[2] is the object set forth, more or less aptly, in the prefaces of twoscore college texts. Hundreds of courses, described in the curriculum as "Chemistry I—general chemistry, lectures and laboratory work," are given each year, more or less successfully attaining this object. From the student's point of view, a firm foundation of chemical science with a year's training in scientific methods of work and scientific habits of thought is shooting wide of the mark. Judged by standards of interest and utility for the majority, it would be more profitable to teach ice-skating to the Hottentots.

Those who have given thought to this subject will not even debate these facts. It is conceded that pandemic chemistry, suggested by Bancroft,[3] serves the needs of the average student better by treating chemistry as a cultural subject. Such a course—the pioneer, I believe—was introduced tentatively at Marshall College under Professor Phelps two years ago, and at Harvard, Yale and Cornell, possibly elsewhere, too, similar experiments are being made. The subject is in the air—very much in the air—but the thought seems to be condensing that two distinct Chemistry I courses, professional and pandemic, must of necessity be developed best to serve the different needs of students who plan to follow medicine, engineering, or one of the natural sciences and those who will make no professional use of chemistry.

This thought I would examine in its nascent state. It will be easier to analyze before it crystallizes.

For this task I have no professional equipment. However, during the better part of ten years, I have served as liaison officer between the three groups who, after all, are most concerned with the practical results of chemical education; the industrial chemists, the chemical manufacturers and the industrial consumer of chemicals. From this coign of vantage it is my business to survey the chemical fields without becoming lost in the towering forests of chemical theory or being bemired in the swamps of chemical commercialism. This point of view is certainly interesting and perhaps helpful.

The time when a knowledge of the Greek and Roman classics was the hallmark of an educated man has past. To-day, even their cultural value is fast diminishing. To know Eros is nowadays not so important as to know what Freud believes about love. The fire Prometheus stole is less use to us than the energy generated by photosynthesis. Phoebus's chariot has become an internal combustion engine; radio replaces Mercury; the metamorphosis of cellulose into rayon, lacquers, celluloid, artificial leather, explosives and what not transcends the myths told

[1] Harvard, Yale, Princeton, Williams, Virginia, Ohio State, Michigan, Illinois, Northwestern and California. The records are not satisfactorily complete for this purpose; but the data are sufficient to assure representative results. Technical schools and universities where engineering courses are notably stressed were purposely omitted.

[2] Alexander Smith, "Inorganic Chemistry."

[3] Walter D. Bancroft, *Jl. Chem. Educat.*, 3, 396 (1926).

by Ovid. Chemistry, physics and biology are to-day not only "a systematized and co-ordinated body of facts," they are also the tools and the toys of the man on the street. They are at once the subject of erudite monographs by specialists and of common gossip around the tea table. Their laws govern the operation of our factories; their principles are applied in the kitchen; their technical terms have become newspaper jargon. In the marketplace or by his own fireside a man is deaf, dumb and blind without at least a working knowledge of the sciences. They are, as Br'er Rabbit said, "de mos' kulturines' t'ing in de world."

The case for chemistry as culture is easily proved; but what of the student who intends to use chemistry in a scientific or engineering career? Should he have, as it were, a professional foundation in chemistry substantial along the lines of the present courses in Chemistry 1? Or would he profit more by an historical and philosophical introduction to the science which would make clear its relationships to all human knowledge and emphasize the important rôle chemistry plays in art, agriculture and especially in modern industry.

In the first place, not one college student in a hundred has any clear, predetermined plan for his life's work. He has no notion whether he will become a chemist or a chiropodist. Too often chance makes this most important decision for him. So often, in fact, that it prompts us to question the present methods of teaching the sciences. When chemistry is presented to the student as a coordinated body of scientific knowledge, as in the course in general chemistry, it can not but appear so complete, so closely knit that he forms no conception of its gradual development in the service of mankind. Because he knows nothing of the long series of lucky accidents, of bold hypotheses, of painstaking studies, that have gradually built up this hard-won knowledge of ours, he fails utterly to comprehend the fundamental sequence of practical application, theory and established scientific fact. Accordingly, he does not put chemistry in its proper relationships with the other sciences, and he can not appreciate its importatnce in the development of our modern industrial civilization. In his general chemistry course he fits together, as in a jig-saw puzzle, a jumble of laws and formulas; but he can not place them in the broader picture of human experience and everyday existence. The result is that he lashes his memory while, too often, his interest lags. The pathetic enthusiasm roused, among both undergraduates and postgraduate students, when I have lectured to them on the commercial organization and economic functions of the chemical industry show how stimulating is a tangible contact with these workaday realities.

In the second place, there are all the obvious dangers of early specialization. Certain swift-moving, far-reaching changes within the growing chemical industry, which will surely be reflected in chemical science, make these dangers, at this time, particularly grave.

During the last three decades of the nineteentth century the spirit of pure science surged strong through every branch of chemistry. This was no altruistic ideal: it was an inspiration as vivid and forceful as medieval religion. Facts, new facts, more facts were greedily sought. Inductive reasoning was so lauded and philosophical theorizing so damned that many good chemists actually believed that any chemical problem might be solved merely by observing with sufficient accuracy a sufficient number of chemical reactions. Chemistry was not the only science which suffered from overdoses of unadulterated Baconism, and there were even certain compensating advantages. A splendid treasure house of recorded analysis and synthesis was built, although much of all this good work was scientific only in its amazing technical precision. This laboratory dexterity—truly more an art than a science—was a curious, but very useful fruit of that era of inductive science.

That treasure house of chemical facts has been drawn upon heavily by the great chemical industry which, thanks to that technical skill, has been developed during the past forty years. Chemical processes have multiplied throughout all industries, and the consumption of chemicals vastly increased. Like a rolling snowball, every new commercial application of chemistry has brought with it other processes and new products. The coal-tar dyes, as a familiar example, have helped to revolutionize the bleaching of textiles and the tanning of leathers. All this chemico-industrial activity created an economic demand for chemically trained men, a demand our universities and technical schools have been striving to fill with that exotic hybrid, the chemical engineer. The whole spirit of chemical education has been so changed that pure science has become a pale and impractical ideal; courses must be practical; and research, subsidized by industry, is scientific only in the journalistic sense of that much overworked adjective.

In the meantime the chemical industry has gone forward by leaps and bounds. Vigorously stimulated by the war, spurred on by the keen competition resulting from over-production; ably assisted by the world's best chemical brains, it not only dominates, it is even beginning to lead, chemical science. Certainly, our industrial application of both catalytic

action and bacterial fermentation is fast outstripping our knowledge of the chemistry involved. While in the past, great chemical discoveries have been personal achievements, to-day they are the carefully plotted results of directed, organized staff research. Formerly, gifted chemists of rare vision and patience, aided by a faithful student or two, have hunted down chemical secrets. Now, corps of chemists, in elaborate laboratories, fitted with every modern appliance and reinforced by libraries stored with the accumulated chemical experience of the past, are besieging chemical problems. These research armies are made up of specialists, each working on some particular phase or part of a general problem which he often but dimly apprehends. Need one press further the dangers of too early specialization on the part of professional students of chemistry?

These dangers are obvious even to our industrialists who lead a movement to foster work in pure science. The fountainheads of our scientific knowledge must be cleansed and revivified. This requires men armed for inductive reasoning with all the chemical facts we have accumulated and all the chemical technique we have acquired. But, above all else, they must be men of courage and imagination who will throw into the chaos of the unknown the grappling irons of deductive theory.

Not only for training such scientists, but also for attracting men of the requisite bold devotion to the science, I submit that a foundation of chemical history and the philosophy of chemistry is best. Such a course, while admirably fitted to the needs of the average student, would be no sinecure. In presenting chemistry historically, from the caveman's discovery of fire, of tanning, of ore smelting to the isolation of Illium and the perfection of the Mont Cenis process of ammonia synthesis, showing how empirical application preceded scientific knowledge and tracing out chemical theory checked by experiment, such a course in pandemic chemistry would cover all the ground of the present Chemistry I. Thus, even for the professional student, little time would be lost. Plainly he would then begin professional study with an understanding of chemistry's true and proper place and an appreciation of the nature of chemical problems that would be invaluable in coordinating his work and rationalizing his generalizations.

WILLIAMS HAYNES

NEW YORK, N. Y.

SCIENTIFIC EVENTS

THE PUTNAM BAFFIN ISLAND EXPEDITION

SAILING under the auspices of the American Geographical Society, the Museum of the American Indian, Heye Foundation, the American Museum of Natural History and the Buffalo Society of Natural Sciences, George Palmer Putnam, publisher and explorer, will lead this summer another expedition to the Arctic Circle.

Last summer Mr. Putnam headed the American Museum Greenland Expedition to North Greenland regions and brought back extensive zoological collections for the museum. This year's expedition will be known as the Putnam Baffin Island Expedition. Mr. Putnam expects to sail from New York in June. This trip, like the one last summer, will be made on Captain Robert A. Bartlett's two-masted schooner *Morrissey*.

The probable route of the expedition, subject to seasonal ice conditions, will be westerly through Hudson Strait and thence north into the Fox Basin district, which is less known than any other similar area on the North American continent. Some of it, so far as mapping is concerned, has remained virtually untouched since the original visit of Luke Fox in 1631. Expeditions into the interior of Baffin Island will be attempted.

Professor L. M. Gould, of the department of geology of the University of Michigan, will be in charge of the geographical work. His assistants will be Robert E. Peary, George Baekeland, Wallace R. Hawkins and George Weymouth.

The expedition's anthropological activities will be carried on in behalf of the Museum of the American Indian, Heye Foundation, which will be represented by Donald A. Cadzow. The zoological collecting for the American Museum of Natural History will be done by Fred Limekiller, a member of last year's expedition. Oceanographic work will be conducted for the Buffalo Society of Natural Sciences. Specimens will be collected by plankton nets and dredging.

THE ANNUAL MEETING OF SCIENCE SERVICE

THE annual meeting of Science Service, Inc., the institution for the popularization of science, was held on April 28 and two new members of the board of trustees were elected. Dr. David White, home secretary of the National Academy of Sciences, was named by that body as one of its three representatives upon the board, and Marlen E. Pew, editor of the weekly publication, *Editor and Publisher*, was chosen a representative of the journalistic profession. Trustees who were reelected were: Dr. D. T. MacDougal, director of the Desert Laboratory, Tucson, Ariz., representing the American Association for the Advancement of Science; Dr. C. G. Abbot, acting secretary of the Smithsonian Institution, representing the National Research Council; Thomas L. Sidlo, of Cleveland, Ohio,

representing the E. W. Scripps Estate; John H. Finley, of the New York *Times*, representing the journalistic profession.

Dr. W. E. Ritter, director emeritus of the Scripps Institution for Oceanography and instrumental in the organization of Science Service, was again chosen president. Dr. Vernon Kellogg, permanent secretary of the National Research Council, was elected vice-president and chairman of the executive committee, and Dr. J. McKeen Cattell, editor of SCIENCE, was elected treasurer. These officers, with Dr. White and Mr. Pew, were chosen to constitute the executive committee.

Trustees whose terms of office have not yet expired and the organizations they represent are: American Association for the Advancement of Science, Dr. J. McKeen Cattell and Dr. M. I. Pupin; National Academy of Sciences, Dr. John C. Merriam and Dr. R. A. Millikan; National Research Council, Dr. Vernon Kellogg and Dr. Victor C. Vaughan; journalistic profession, Mark Sullivan; E. W. Scripps Estate, Dr. William E. Ritter and Robert P. Scripps.

Reports from the director, Dr. Edwin E. Slosson, and the managing editor and secretary, Watson Davis, were received and discussed at the meeting.

In the course of the writing and editing of its newspaper syndicate services, magazine articles, books, radio talks and lectures, Science Service produces some 2,200,000 words and 1,300 illustrations, which have an aggregate circulation of some 14,500,000. One service alone, the daily *Science News Bulletin*, goes to 76 newspapers and other publications and a survey of the utilization of these news releases shows that over 3,500,000 newspaper subscribers have the opportunity to read about 260 words of Science Service news reports each day.

The various newspaper services of Science Service now include: daily *Science News Bulletin*, daily "Why the Weather," daily "Nature's Notebook," weekly "Illustrated Feature," weekly "Science Shorts," monthly "Star Story Map," weekly "Isn't It Odd," daily "Current Radio," weekly "Condensed Service," "Special Wire Services," daily "Ask Yourself," a series of "Baby Tests," a series on "The Mechanics of Golf," etc.

The successful establishment of the *Science News-Letter* as a printed weekly magazine, with a circulation of over 5,500, was reported to the trustees. The *Science News-Letter* is available for personal subscription only.

Another important branch of the work of Science Service is the editing of books for various publishers. Its lectures, notably those of its director, Dr. Slosson, reach many thousands yearly and a group of nearly twenty radio stations broadcast a regular radio talk on science furnished them by Science Service. By contributing to leading periodicals through regular departments and occasional articles, Science Service places before many thousands of people reports and interpretations of scientific progress.

WATSON DAVIS,
Managing Editor

WASHINGTON, D. C.

THE FORTIETH ANNIVERSARY OF THE DENISON SCIENTIFIC ASSOCIATION

EXERCISES commemorating the fortieth anniversary of the founding of the Denison Scientific Association were held at Denison University, Granville, Ohio, on April 19. Commemoration addresses were delivered by Dr. C. Judson Herrick, professor of neurology at the University of Chicago; Dr. Frank Carney, consulting geologist of the National Refining Company, and Alfred D. Cole, professor of physics at the Ohio State University.

In connection with the celebration a series of general addresses have been given as follows: April 13, Professor Robert A. Millikan, director of the Norman Bridge Laboratory of the California Institute of Technology, "Science and Religion"; April 20, Dr. Kirtley F. Mather, professor of geology at Harvard University, "Forty Years of Scientific Thought concerning the Origin of Life"; April 27, Dr. George A. Dorsey, author of "Why We behave like Human Beings," "Charles Darwin, a Pioneer in Experimental Evolution."

This association was organized April 16, 1887, and has been active ever since that time. The moving spirit in founding the association was Dr. Clarence Luther Herrick, and among the charter members were A. D. Cole, now head of the department of physics of the Ohio State University; W. E. Castle, of the Bussey Institution of Harvard University; C. Judson Herrick, professor of neurology, University of Chicago; August F. Foerste, paleontologist; W. H. Cathcart, director of Western Reserve Historical Society, and George F. McKibben, now teacher in a college at Saltillo, Mexico.

The *Journal of the Scientific Laboratories of Denison University* has been published since 1885, and has a distinguished list of domestic and foreign exchanges.

In these days of large institutions, it is rather unusual to find a small college with less than a thousand students supporting an organization like the Denison Scientific Association and the publication issued by it.

W. C. EBAUGH,
Permanent Secretary

THE RENO MEETING OF THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION

THE preliminary announcement of the Reno meeting of the Pacific division of the American Association for the Advancement of Science to be held from June 22 to 24, at the University of Nevada, has been issued to the membership. It is an attractive illustrated folder of sixteen pages issued by the executive committee of the Pacific division and containing a warm welcome from the University of Nevada to the visiting scientists.

Many distinguished men will be in attendance and the meeting promises to be a great success. President Arthur A. Noyes will preside and deliver an address on "Periodic Relations of the Elements." Professor Henry H. Dixon, of the University of Dublin, will speak on the "Nerves of Plants."

A symposium on "The Scientific Problems of an Arid Region" will be an outstanding feature with Professor Gilbert Smith, of Stanford University, presenting the subject of botany; Professor Tracy I. Storer, of the University of California, zoology, and Professor J. Claude Jones, of the University of Nevada, geology.

At a general session to be held on Thursday, June 23, reports on recent achievements in research in Pacific Coast laboratories will be given as follows:

Astronomy—Walter S. Adams, director, Mount Wilson Observatory.
Physics—Leonard B. Loeb, professor of physics, University of California.
Chemistry—E. C. Franklin, professor of organic chemistry and dean of graduate study, Stanford University.
Botany—Charles B. Lipman, professor of plant nutrition and dean of the graduate division, University of California.
Zoology—C. V. Taylor, professor of biology, Stanford University.
Medicine—P. J. Hanzlik, professor of pharmacology, Stanford University.

President Walter E. Clark, of the University of Nevada, will welcome the delegates. Ample accommodations will be provided for the various sessions on the campus of the university.

Among several interesting excursions offered for the entertainment of visitors will be an all day automobile trip to Pyramid Lake, the "Lake of the Desert," and one to Virginia City and Carson City where the famous prehistoric foot prints will be viewed.

Thirteen affiliated scientific societies are planning to hold meetings under the auspices of the Pacific Division as follows:

American Association of Economic Entomologists
Pacific Slope Branch
American Chemical Society
California Section
Puget Sound Section
Southern California Section
American Physical Society
American Phytopathological Society
Pacific Division
Astronomical Society of the Pacific
Botanical Society of America
Physiological Section
The Ecological Society of America
Pacific Coast Entomological Society
Paleontological Society
Pacific Coast Branch
San Francisco Aquarium Society
Western Agricultural Economists
Western Plant Quarantine Board
Western Society of Naturalists

Although Reno is somewhat remote from the centers where the majority of the members reside there is wide interest in this meeting and many are planning to make the trip through the Sierras over the new highway. A large attendance seems assured.

W. W. SARGEANT,
Secretary

SCIENTIFIC NOTES AND NEWS

DR. WILLIAM H. WELCH, professor of the history of medicine at the Johns Hopkins Medical School, has been awarded the 1927 medal for scientific research in medicine by the Association of American Physicians.

DR. LUDVIG HEKTOEN, professor of pathology at the University of Chicago and director of the McCormick Institute for Infectious Diseases, has been elected a member of the Norwegian Pathological Society in Oslo.

PROFESSOR WILLIAM M. WHEELER, dean of the Bussey Institution of Harvard University, has been awarded the Dollfus prize of the French Entomological Society.

THE medal awarded annually by the American Institute of Chemists to the chemist whose work has been of outstanding value to science was presented to Professor Lafayette Benedict Mendel, of Yale University, on May 11 at the Chemists' Club in New York City. Dr. Graham Lusk, of Cornell University, presented Professor Mendel's credentials for the medal, while Dr. Treat B. Johnson, of Yale University, president of the institute, made the formal presentation. In

response, Professor Mendel read a paper dealing with chemical education.

A PUBLIC reception in honor of Dr. William B. Mayo on his completion of a half century in the practice of medicine took place at Northfield, Vt., on April 15. The speakers included the president of Norwich University, of which school Dr. Mayo has been a trustee for forty years; Professor Charles H. Spooner, and Drs. William Wheeler, John H. Judkins and Frank Lynde.

DR. F. B. MUMFORD, dean of the college of agriculture at the University of Missouri, was the recipient of the honorary degree of doctor of agriculture, conferred by the University of Nebraska on April 13. Dean Mumford addressed the members of the faculty and the student body at commencement on "Agriculture in the New Era."

DR. HENRY MILLS HURD, first superintendent of the Johns Hopkins Hospital and for many years professor of psychiatry, celebrated his eighty-fourth birthday on May 3.

THE University of California has conferred the degree of doctor of laws upon Professor H. H. Turner, of Oxford University, who recently gave a course of lectures in astronomy at the university.

DR. H. J. VAN CLEAVE, professor of zoology at the University of Illinois, was elected president of the Illinois State Academy of Science at its recent session in Joliet. C. F. Phipps, of De Kalb, was elected *vice-president;* L. J. Thomas, of the University of Illinois, *secretary;* George T. Fuller, of the University of Chicago, *treasurer,* and A. B. Crook, of Springfield, *librarian.*

PROFESSOR THEODORE W. RICHARDS, of Harvard University, and Professor James F. Norris, of the Massachusetts Institute of Technology, have been appointed honorary chairman and honorary vice-chairman, respectively, of the seventy-sixth meeting of the American Chemical Society, which will be held in September, 1928, at Swampscott, Mass., under the auspices of the Northeastern section of the society. The general chairman is Dr. Gustavus J. Esselen, Jr., vice-president of Skinner, Sherman, and Esselen, Inc., Boston, Mass., and the executive secretary is Professor Lester F. Hamilton, of the Massachusetts Institute of Technology.

PROFESSOR FRANK C. WHITMORE, chairman of the chemistry department at Northwestern University, is to be on sabbatical leave during 1927–28. He will spend the year in Washington as chairman of the division of chemistry and chemical technology of the National Research Council. Professor Whitmore has been appointed a member of the central petroleum committee of the National Research Council and the American Petroleum Institute. This committee has charge of the research funds donated by John D. Rockefeller and by the Universal Oil Products Company.

THE executive board of the National Research Council of Washington, D. C., has elected Dr. Dayton C. Miller, head of the physics department of Case School of Applied Science, to the position of chairman of the division of physical sciences. Dr. Miller will continue his work at the Case School and will have offices in Washington to which he will go frequently. Dr. Miller succeeds Professor J. S. Ames, provost of the Johns Hopkins University, who has resigned after three years as chairman of this division.

AT the recent meetings of the Society of Biological Chemists, Professor H. C. Sherman, Mitchill professor of chemistry at Columbia University, was chosen to represent the society in the division of medical sciences of the National Research Council. His term is for three years and begins on July 1.

DR. HOMER F. SWIFT, of the Rockefeller Institute, was elected president of the American Society for Clinical Investigation at the nineteenth annual meeting at Atlantic City. Other officers elected were Dr. S. S. Strouse, Chicago, *vice-president;* Dr. J. F. Wearn, Boston, *secretary;* Dr. George Sorrop, Brooklyn, *treasurer,* and Dr. Dean A. H. Graham, Toronto, *councillor.*

DR. S. W. PARR, professor of chemistry at the University of Illinois, was elected a member of the council of the American Chemical Society, to succeed Dr. George D. Rosengarten, now president of the society, at the recent Richmond meeting.

DR. JOSEPH W. SCHERESCHEWSKY, for several months in charge of the federal quarantine station in Boston, has been relieved by Dr. Alvin R. Sweeney, who has been transferred from Port Arthur, Texas. Dr. Schereschewsky will return to the Harvard University Medical School.

THE Provincial Government of Manitoba has appointed Professor R. C. Wallace, of the department of geology and mineralogy of the University of Manitoba, commissioner of mines.

ON the invitation of Dr. Henry A. Christian, Dr. David Riesman, of the University of Pennsylvania, acted as physician-in-chief *pro tem.* of the Peter Bent Brigham Hospital, in Boston, during the last week of April.

THE New York Post-Graduate Medical School and Hospital has engaged Dr. Edward H. Hume, recently president of Yale-in-China, to make a comprehensive investigation and report upon its activities. Dr. Hume has already begun work on this survey and will continue for several months.

C. H. HADLEY has resigned as director of the bureau of plant industry of the Pennsylvania Department of Agriculture to accept appointment in the Federal Bureau of Entomology. After May 1 he will work at the Corn Borer Office, Toledo, Ohio, in connection with the European corn-borer project.

DR. GEORGE GRANT MACCURDY, of Yale University, director of the American School of Prehistoric Research, has been appointed a member-at-large of the division of foreign relations of the National Research Council. Dr. and Mrs. MacCurdy will leave for Europe on May 19 to do reconnaissance work in prehistory prior to the opening of the summer term of the American School of Prehistoric Research on June 27.

DR. HARLAN T. STETSON, of the astronomical laboratory of Harvard University, has been appointed research assistant of the Smithsonian Institution, and will accompany the McCormick-Chaloner eclipse expedition under the auspices of the Smithsonian Institution to Norway for the purpose of observing the total eclipse of the sun on June 29.

DR. WEGNER, professor of anthropology at the University of Frankfurt, has been chosen by the German minister of science, arts and education to conduct the 1928 expedition to Bolivia of the Frankfurt Society of Anthropology, Ethnology and Paleontology.

DR. WILMONT C. FOSTER, assistant professor of anatomy at the University of Oregon Medical School, will continue work in surgical anatomy at the Mayo Clinic, Rochester, during a year's leave of absence which has recently been granted him.

DR. JIRI V. DANES, professor of general geography of the faculty of natural sciences at Prague, plans to spend the next academic year in the United States, giving lectures and studying the limestone regions.

DURING the present semester, Dr. S. Van Valkenburg, for five years director of the topographic division of the government work in Java, is lecturing on "The Geography of the Far East," and on "The Economic Geography of Europe," at the Clark University School of Geography. Dr. Bruno F. A. Dietrich, of the Technical Institute of the University of Breslau, is lecturing on "The Economic Geography of Central Europe." Dr. Dietrich has traveled widely in the United States this year, and plans to return next year.

DR. S. C. LIND, dean of the school of chemistry of the University of Minnesota, addressed the chemical colloquium of the University of Virginia on April 26, on "The Chemical Effects of Radon."

PROFESSOR JAMES HOWARD MCGREGOR, of Columbia University, delivered a lecture under the auspices of the department of zoology at Oberlin College, on April 13, on "Races of Prehistoric Man." Dr. McGregor will address the New York University chapter of the Sigma Xi on May 17, at 8:15, in the medical school buildings.

PROFESSOR CHARLES J. CHAMBERLAIN, of the University of Chicago, delivered the Sigma Xi address at Indiana State University, on April 14, on "Botanical Experiences in the Tropics."

DR. CHARLES F. BROOKS, professor of meteorology and climatology at Clark University, gave a public lecture at the Chabot Observatory, Oakland, Calif., on April 29, on "The Problem of forecasting Seasons." Dr. Brooks has been working at the Scripps Institution of Oceanography, La Jolla.

PROFESSOR HENRY B. WARD, of the University of Illinois, spoke by invitation at the research club of the Johns Hopkins School of Hygiene and Public Health on April 26. His subject was the "Fish Tapeworm Problem in North America."

PROFESSOR SELIG HECHT, department of biophysics, Columbia University, delivered a lecture on vision to the combined seminars of biology and psychology at Clark University on April 21.

LOUGHNAN S. PENDRED, editor of *The Engineer*, London, is to give an after-dinner talk on Wednesday evening, May 25, at the White Sulphur Springs meeting of the American Society of Mechanical Engineers.

THE Linacre lecture at the University of Cambridge was delivered on May 6 by Dr. J. A. Murray, director of the Imperial Cancer Research Fund, on "Multiple New Growths."

ACCORDING to an Associated Press dispatch, France celebrated the centenary of the birth of Pierre Eugene Marcelin Berthelot by launching a national subscription for the erection of a "House of Chemistry." The ceremony took place at the Sorbonne, presided over by M. Painlevé, Minister of War. Numbers of scientific men and diplomats of all nations attended.

DR. THOMAS FORSYTH HUNT, professor of agriculture at the University of California and formerly dean of the college of agriculture, recently died on shipboard while returning from a visit to Honolulu. Dr. Hunt was sixty-five years old.

HUDSON MAXIM, the inventor, died on April 6 at the age of seventy-four years.

DR. JOHN GOODRICH CLARK, who has occupied the chair of gynecology at the University of Pennsylvania Medical School for twenty-seven years, died on May 4 in his sixtieth year.

DR. S. W. RICHARDSON, formerly principal and professor of physics at University College, Southampton, died on April 10, aged fifty-seven years.

DR. ADOLPH MIETHE, professor of chemistry in the Berlin Institute of Technology, died on May 5, aged sixty-five years.

THE United States Civil Service Commission states that since the recent announcement of an examination to fill the vacant position of chief of the Bureau of Chemistry and Soils, in the Department of Agriculture, the salary of the position has been raised to $7,500 a year. This necessitates a new examination and all qualified persons are urged to apply. In view of the importance of the position in the field of chemistry and soils, and to insure the appointment of a thoroughly qualified man, the commission will follow its committee method of competitive examination for filling this position. It is probable that the position of associate chief of the same bureau, at a salary of $6,000 a year, will also be filled from the register of eligibles established as a result of this examination. The duties of the position of associate chief will be to assist the chief in administering the activities of the bureau. Applications must be received not later than June 7. Full details were printed in SCIENCE, March 4, 1927, page 224.

THE American Society of Zoologists will hold its twenty-fifth annual meeting on Wednesday, Thursday, Friday, December 28, 29 and 30, 1927, at Nashville, Tennessee, in conjunction with Section F of the American Association for the Advancement of Science.

THE tenth annual meeting of the Northwestern Association of Horticulturists, Entomologists and Plant Pathologists will be held at the University of Idaho, Moscow, Idaho, and at the State College of Washington, Pullman, Washington, on June 27, 28 and 29. These two institutions are but nine miles apart.

WE learn from *Nature* that at the anniversary meeting of the Linnean Society to be held on May 24, the following medals will be awarded: The Linnean Medal in gold, given each year to an eminent biologist as an expression of the society's estimate of his services to science, usually to a botanist and a zoologist in alternation, will be presented to Dr. Otto Stapf. Dr. Stapf has served as keeper of the Herbarium at Kew, and is now the editor of the *Botanical Magazine*. The Crisp Award was established by a donation of £200 by the late Sir Frank Crisp, for the best paper dealing with microscopical research by a fellow of the society since the last award, and is made at intervals of five years, accompanied by a medal in bronze and the balance of the income of the principal. The recipient this year will be Professor Herbert Graham Cannon, professor of zoology in the University of Sheffield, for a paper on the "Post-Embryonic Development of the Fairy Shrimp," issued last year in the zoological journal of the society.

THE American Council of Learned Societies has received from the Carnegie Corporation a subvention of $10,000 a year for five years, beginning with 1927, for the recording and investigation of American Indian languages. It has entrusted the direction of this work to a committee consisting of Franz Boas, *chairman*, Edward Sapir, and Leonard Bloomfield. There is also an advisory board consisting of Roland B. Dixon, Pliny E. Goddard, John P. Harrington, A. L. Kroeber, D. Jenness, Truman Michelson, Frank G. Speck and John P. Swanton.

DR. E. D. MERRILL, dean of the College of Agriculture of the University of California, has been appointed director of the California Botanical Garden at Los Angeles, effective on June 1, on partial leave of absence from the university. His new work will be to direct the organization and to develop this potentially large institution which is already heavily endowed in land. Approximately 3,200 acres of land have been turned in on deed of trust to the Metropolitan Trust Company, and all profits accruing from the sale of the lands for residential purposes surrounding an 800-acre garden will form the endowment of the institution under the immediate direction of the Garden Foundation, Inc., a non-profit, non-stock corporation, organized for scientific, educational and charitable purposes. The garden site includes all the Mandeville Canyon extending from Beverly Boulevard to Mulholland Drive in the Santa Monica Mountains, near the new site of the University of California at Los Angeles.

IN furthering plans for developing the Blandy Experimental Farm, which was acquired under the devise of the late Graham F. Blandy, the University of Virginia has recently announced the appointment of Dr. Orland E. White, curator of plant breeding and economic plants at the Brooklyn Botanic Garden, as professor of agricultural biology and director of the experimental farm. Also, five research fellowships have been established; two carrying a stipend of $1,000 each, and three $500. The holders of these fellowships will be exempt from paying tuition fees. Graduates from standard colleges who have majored in

biology or agriculture will be eligible candidates. Appointees are expected to register in the graduate department at the University of Virginia and to take work leading towards a higher degree.

ANTICIPATING the federal quarantine against the importation of nursery stocks which becomes effective in 1930, the New York Legislature has appropriated $18,850 for comprehensive investigations on nursery stock production at the State Agricultural Experiment Station at Geneva. Part of the appropriation is made immediately available in order that work on the project may begin at once. H. B. Tukey, for several years in charge of the horticultural investigations of the Geneva Station in the Hudson River Valley, has been designated to take over the nursery work at Geneva and will enter upon his new duties at an early date.

THE U. S. National Museum has recently received the collection of Lepidoptera, made some years ago by Mr. Henry F. Schoenborn, of Washington, D. C. Mr. Schoenborn was born in Suhl, Thuringia, Germany, in 1833, and died in Washington in 1896. He was one of the early amateur entomologists of Washington. The collection includes to a large extent the local fauna with the addition of a considerable series from Europe, all well mounted and in fine condition. The gift is a donation of the surviving daughter and son, Miss Theresa F., and William E., Schoenborn.

ATTEMPTS to break the will of the late R. J. McDonald, who left a bequest of $1,125,000 to the University of Texas, have been unsuccessful. The money is to be used for the construction and equipment of an astronomical observatory, plans for which are in charge of Dr. H. Y. Benedict, dean of the college of arts and sciences.

AN allotment of $130,000 has been made the University of Oregon Medical School by the General Education Board. This fund is to be used for traveling expenses, the improvement of equipment, additional salaries and volumes for the school library and such expenditures as are not provided for by the state legislature.

AN appropriation of $60,000 has been made by the State of Montana for the establishment of a new entomological laboratory to be located at Hamilton. Approximately $25,000 per year has also been appropriated to carry on research on Rocky Mountain spotted fever.

COLUMBIA UNIVERSITY will receive $15,000 under the will of the late Dr. Henry Koplik, specialist in children's diseases, to be used for the establishment of a scholarship for the study of children's diseases.

ACCORDING to a cable to the New York *Times*, Edmond de Rothschild has donated 30,000,000 francs to be used in establishing a French foundation patterned after the Rockefeller Foundation in America. It will be known as the Institute of Physico-Chemical Biology. Four well-known scientists will form the first board of directors. They are Jean Perrin, winner of the Nobel Prize for physics, Professor Job, of the Sorbonne, Professor Mayer, of the College of France, and Pierre Girard, director of the School of Higher Studies at the Sorbonne.

THE Army Medical Department has been notified that the gold medal of the international committee of the Red Cross had been awarded to it in the competition of "wound cards" recently held at Geneva in connection with the meeting of the International Standardization Committee.

UNIVERSITY AND EDUCATIONAL NOTES

CORNERSTONES for two new scientific buildings to cost $2,000,000, an engineering building and a chemical laboratory, were laid at Princeton University on May 12.

AN additional gift of $250,000 to the University of Chicago for building the George Herbert Jones laboratory of chemistry has been made by Mr. Jones. This brings Mr. Jones's total gift to $665,000, the sum of $415,000 having been given by him last December.

THE Scott bill providing a total appropriation of $4,234,500, including one million dollars for new buildings and plant repairs for the Pennsylvania State College, was given approval by the state legislature in the closing days of its session. The funds provided in the bill, in addition to the building item, include $2,181,000 for general college maintenance, $403,500 for agricultural research and $650,000 for agricultural and home economics extension.

THE establishment of the William Allan Neilson chair of research at Smith College is the gift of friends and admirers of Dr. Neilson in honor of the tenth year of his presidency. The chair will be held five years by Professor Kurt Koffka, of the University of Giessen, who is at present visiting professor at the University of Wisconsin.

DR. JOHN BOWLER has been elected dean of the Dartmouth Medical School.

DR. HOMER L. DODGE, head of the department of physics of the University of Oklahoma, has been appointed dean of the graduate school, succeeding Dr. A. H. Van Vleet, who was dean from 1909 until his death in 1925.

DR. EDWARD S. ROBINSON, of the department of psychology at the University of Chicago, has been appointed professor of psychology at Yale University.

DR. J. M. D. OLMSTED, assistant professor of physiology at the University of Toronto, has been appointed associate professor of physiology at the University of California.

DR. GEORGE H. KIRBY, director of the New York State Psychiatric Institute and professor of clinical medicine in the department of psychiatry at Cornell University Medical College, has been appointed professor of psychiatry at Columbia University. Dr. Kirby sailed for Europe on April 23 to visit neuropsychiatric clinics and hospitals.

DR. VIRGIL H. MOON, head of the department of pathology in the Indiana University School of Medicine, has been appointed head of the department of pathology at Jefferson Medical College, Philadelphia, and will assume his duties in June.

DISCUSSION AND CORRESPONDENCE

HUMIDITY AND CHRONOMETRY

MANY of those interested in well-regulated timepieces have doubtless noticed the tendency of watches to run fast in winter and slow in summer. This variation is in the direction to be expected from incomplete temperature compensation, but most watches are kept nearly as warm in winter as in summer. The indoor humidities however vary from about 30 to 80 per cent. from winter to summer. Being interested in adsorbed films it occurred to me to investigate the effect of varying humidities on the amounts of water adsorbed by metals in relation to watch rates.

Through the courtesy of Mr. George P. Luckey, of the Hamilton Watch Company, a dozen balance wheels were obtained for test. These weighed 5.13035 grams after exposure to a saturated atmosphere, 5.1302 at 40 per cent. humidity, 5.1300 at 5 per cent. humidity and 5.1291 grams with the moisture completely removed. The total surface exposed was approximately 8 sq. cm, hence the moisture was adsorbed to a depth of 1.6 microns or about 4,000 molecular diameters. The relative change in mass was as 1 : 1.00025 for all the adsorbed water and about a tenth as much for the range of indoor humidities ordinarily met with.

A gravity pendulum is of course not affected by such variations in mass since force and mass vary in the same proportion. But in watches and chronometers, the force applied by the activating spring is independent of the mass moved and a variation in that mass produces a first order effect on the rate. Since $(t_1/t_2)^2 = I_1/I_2 = m_1/m_2$, a change in rate of 1 second per day would be produced by a change in mass from 1 to 1.000023. Removal of all the adsorbed moisture from the balance wheel of a watch or ship chronometer would therefore cause it to gain about 10 seconds per day. Variations in humidity from 30 to 80 per cent., other things being equal, would cause changes in rate of 20 to 30 seconds per month. The rating of a ship chronometer in a dry winter land laboratory could not hold for protracted humid conditions.

Since the adsorbed moisture layer decreases rapidly in thickness with rise of temperature, thermal expansion and moisture adsorption tend to compensate each other in chronometers. Control of humidity within the case should not be difficult. The adsorption of the vapors of lubricating oils is relatively much less and this too could be brought under control if necessary.

P. G. NUTTING

U. S. GEOLOGICAL SURVEY,
WASHINGTON, D. C.

SIXTY-ONE NAMES UNDER CONSIDERATION FOR INCLUSION IN THE OFFICIAL LIST OF GENERIC NAMES

THE secretary of the International Commission on Zoological Nomenclature has the honor to invite attention of the zoological profession to the fact that the following 61 generic names (with genotypes in parentheses) are under consideration for insertion in the Official List of Generic Names.

Announcement of final vote will be delayed until about April 1, 1928, in order to give persons interested in these names opportunity to express their opinions.

PROTOZOA: *Bursaria* (*truncatella*), *Eimeria* (*falciformis*), *Laverania* (*malariae* so. *falcipara*), *Plasmodium* (*malariae*), *Sarcocystis* (*miescheri*).

CESTODA: *Ligula* (*avium*).

NEMATODA: *Filaria* (*martis*), *Heterodera* (*schachtii*), *Rhabditis* (*terricola*), *Strongylus* (*equi* = *equinum*), *Syngamus* (*trachealis* so. *trachea*).

OLIGOCHAETA: *Enchytraeus* (*albidus*).

HIRUDINEA: *Haemadipsa* (*zeylanica*), *Limnatis* (*nilotica*).

CRUSTACEA: *Armadillidium* (*vulgare* so. *armadillo*), *Astacus* (*astacus*), *Cancer* (*pagurus*), *Daphne* (*pulex*), *Diaptomus* (*castor*), *Gammarus* (*pulex*), *Homarus* (*gammarus* = *marinus*), *Nephrops* (*norvegicus*), *Oniscus* (*asellus*), *Pandalus* (*annulicornis*), *Penaeus* (*monodon*), *Porcellio* (*scaber*).

XIPHOSURA: *Limulus* (*polephemus*).

SCORPIONIDEA: *Scorpio* (*europaeus*).

ARANEAE seu ARANEIDA: *Avicularia* (*avicularia*), *Dendryphantes* (*hastatus*), *Dysdera* (*punctoria*), *Latrodectus* (13-*guttatus*), *Segestria* (*florentina*).

ACARINA: *Cheyletus* (*eruditus*), *Chorioptes* (*ca-*

prae), *Demodex* (*folliculorum*), *Dermanyssus* (*gallinae*), *Glyciphagus* (*domesticus*), *Polydesmus* (*complanatus*), *Psoroptes* (*equi*), *Rhizoglyphus* (*robini*), *Trombidium* (*holosericeum*).

THYSANURA: *Lepisma* (*saccarhina*), *Podura* (*plumbea*).

ORTHOPTERA: *Blatta* (*orientalis*), *Ectobius* (*lapponica*), *Gryllus* (*campestris*), *Periplaneta* (*americana*).

ISOPTERA: *Termes* (*fatale*).

CORRODENTIA: *Atropos* (*lignarium*).

ANOPLURA: *Pediculus* (*humanus*), *Phthirus* (*inguinalis* so. *pubis*).

HEMIPTERA: *Anthocoris* (*nemorum* so. *sylvestris*), *Corixa* (*striata* = *geoffroyi*), *Nabis* (*vagans* so. *ferus*), *Nepa* (*cinerea*), *Notonecta* (*glauca*), *Reduvius* (*personatus*), *Triatoma* (*gigas* = *rubrofasciatus*).

DERMAPTERA: *Forficula* (*auricularia*).

SIPHONAPTERA: *Pulex* (*irritans*).

CH. W. STILES,
Secretary.

CURIOSITIES OF ANTHECOLOGY

KNUTH'S "Handbuch der Blütenbiologie" consists of Band I, 1–400, 1898; Band II, Teil 1, 1–697, 1898, Teil 2, 1–705, 1899; Band III, Teil 1, 1–570, 1904, Teil 2, 1–601, 1905. It is the most important general work on anthecology that has ever been published, summarizing all the literature down to 1903. It gives abstracts of all my flower and insect papers and gives the insect visits of all the species mentioned in them. Band II, Teil 1, 2, contains European and arctic results. Band III, Teil 1, 2, contains results from the rest of the world. I have the satisfaction of knowing that those who ignore my papers also ignore Knuth's work.

Davis' "Knuth's Handbook of Flower Biology" is another thing. Vol. II is Band II, Teil 1, of Knuth's work. Vol. III is Band II, Teil 2. Band III, Teil 1 and Teil 2 have not been translated.

It is remarkable how persons not really interested in this matter should feel impelled to write about it.

In the *Botanical Gazette* we read, "The third volume of the English translation of Knuth's 'Handbuch der Blütenbiologie' has just appeared and completes the work."

In the *American Bee Journal* we find, "A survey of the whole subject may be obtained from the English translation of 'Knuth's Handbook of Flower Pollination,' three volumes published by the Clarendon Press, Oxford, 1906. This admirable treatise has a splendid summary of the more important work done along the lines of pollination up to the year 1906."

In a Carnegie publication, with two authors, it is stated, "No previous floral study of *Rubus* has been made in America, but several European species have received much attention (Knuth, 1908: 352)" and "The pollination of the rose appears to have received no attention in this country, but several species have been studied in Europe (Knuth, 1906: 348)." But Knuth, 1904, Band III, Teil 1, 340, 344, gives abstracts of *Rubus occidentalis* and *villosus*, *Rosa humilis* and *setigera* and cites my "Rosaceae and Compositae" of 1894.

Another paper with two authors says: "Doubtless some of the papers dealing with flowers and bees have been overlooked." This article of 1920 repeats 385 and overlooks 259 of the cases recorded by me, all of them given by Knuth in 1905, Band III, Teil 2.

A paper with two authors involves a trinity, one, the other and both. A fine point of cooperation would be to combine with some one who would do the work and take the blame for any error, while you take the credit.

In "Flowers and Insects" (XXI, *Bot. Gaz.* **73**: 148), I made a fuss about Knuth's volume II repeating Mueller's lists for the third time, while his volume III merely summarizes American lists. The joke is that Davis' "Knuth's Handbook" repeats Mueller's lists for the fourth time, while all mention of American lists is suppressed.

In a letter of December 8, 1919, the Oxford University Press, American Branch of the Clarendon Press, says, "Replying to your letter of Nov. 25th, we beg to say that the 4th and 5th Volumes of Knuth's 'Flower Pollination' have not yet been published, and we regret we have no information as to when they will be ready."

It is evident that the authors cited above as referring to the work thought that all of it had been translated, and that all who bought the first volumes thought that the rest would be translated.

CHARLES ROBERTSON

CARLINVILLE, ILLINOIS

AN EARLY BOOK ON ALGOLOGY

A COPY of one of the rarest botanical works in America has recently been found at Rutgers University. This is "The Algae and Corallines of the Bay and Harbor of New York," published by Mr. C. F. Durant in 1850, said to be the first book on algology published in America. Only two other copies are known to be in existence, one each at the Brooklyn Botanic Garden and the New York Botanical Garden. The work is unique in that every plant described in the text is illustrated by an actual dried specimen, the little cards bearing the plants being pasted on

blank pages, thus forming a very original Icones Algarum.

The history of the book has been described by Hollick[1] and interesting excerpts are given by him from Durant's notes, which now form an invaluable commentary on the floristic (and faunistic) communities of New York Harbor and Raritan Bay before pollution had destroyed them.

It is possible that still other copies are hidden away in our older libraries and can yet be retrieved.

ARTHUR P. KELLEY

RUTGERS UNIVERSITY

SCIENTIFIC BOOKS

Manual of Meteorology, Vol. I. By SIR NAPIER SHAW, with the assistance of ELAINE AUSTIN. Cambridge University Press, 1926, pp. XX + 340, 121 illustrations. Price 30s. net.

THIS volume is part of the monumental work planned by Sir Napier Shaw when he retired from the directorship of the Meteorological Office. That the last shall be first receives a striking confirmation in the issue of the four volumes constituting the work, for the final volume (IV) was handed to the printer on Armistice Day, and duly made its bow to the reading public in 1919. It dealt primarily with wind and pressure; though perhaps pressure should come first, since difference in pressure initiates air flow or wind.

Volume I now appears, and from a personal letter we know that Vol. III is ready for the press. Vol. IV had 166 pages; the present volume (I) has just double that number, and naturally the price also is doubled; but the increase will not be grudged. The present volume carries as sub-title "Meteorology in History"; and the text justifies the heading.

The author gives his viewpoint when speaking of what was expected of him as his bit, during the World War. He says, "It became my duty to supply or alternatively to train officers for various meteorological services." The director was working in an environment "which contained within its own experience or on its shelves almost all that there is to know about the weather"; yet he had to send responsible officers into the services, "with a formula by which they could carry on in place of the knowledge that would enable them to become a part."

This and the feeling that the atmosphere should be studied as a whole led to the conception of a compendium of what had been done by workers in many lands. Furthermore, there lurks in the author's mind a feeling that the study of the atmosphere, that is, aerography, should be thrown open to amateurs, whereas it is now to all intents and purposes limited to a professional few in official harness. He says truly that the study of weather, "which in so far as it is specialized is devitalized," ought to be an attractive subject for amateurs. It is to furnish amateurs with the necessary historic background that this big piece of work was attempted.

The present volume has fifteen chapters, and in every chapter there is plenty that is filling and on the whole easily digestible. The menu ranges from Aristotle's Meteorologica to the equipment of a modern observatory, including radio-integrators, pyranometers and pyrgeometers. The illustrations are abundant and, considering the age of many of the originals, have come out well. The personal touch is shown in photographs of some of the international meteorological congresses.

The pioneers in meteorology were all good-looking men, although running largely to whiskers. In the Paris conference photograph not one of the thirty-four faces is clean shaven. How fashion changes! To-day in a group of fifty airmen there would not be a single face adorned with excess pilosity.

There is one American meteorologist whose face is missing; that is William Ferrel, due probably to Ferrel's modesty. Langley and Maury are present; but Franklin and that earliest explorer of the upper air, Dr. John Jeffries, are missing. Robert Boyle might have been included, for certainly the author of the "Spring of the Air" did a lot to advance knowledge of air pressure.

There is little to criticize in the book, for it is evident that the utmost care has been taken to get dates, names and facts correct. A reviewer can only applaud the author and those who assisted him, for both quality and quantity of work. The type work is excellent, and the Cambridge University Press lives up to its high standard. The book contains 121 illustrations, 95 of which are cloud photographs. No one interested in aerography, the science of the air, can afford to be without the book.

ALEXANDER MCADIE

An Outline of a Reclassification of the Foraminifera. By JOSEPH A. CUSHMAN. Contributions from the Cushman Laboratory for Foraminiferal Research, Vol. 3, pt. 1, 1927, pp. 1–105, 21 plates. Published by the author at Sharon, Mass.

DR. CUSHMAN'S latest work upon these important micro-organisms will be welcomed by all students of this class and particularly by those employed in economic geology. In a former article, issued by the

[1] Hollick, Arthur. "A Quaint Old Work on Seaweeds," Proc. Staten Island Assoc. Arts Sci., vol. 5, parts III and IV, 1915.

Smithsonian Institution in 1925, Cushman dealt with the methods of study and other features of general interest in addition to presenting a bibliography of the most useful works and descriptions and illustrations of important genera. The present article, which in an outline preliminary to a larger treatise, aims to bring order out of the former classifications and to arrange the many genera in natural grouping. Cushman is particularly well fitted for this task, with his twenty-five years of experience in active work upon fossil and recent foraminifera from all parts of the world.

This is the first complete classification of the formaminifera based purely on the study of the ontogeny and phylogeny in conjunction with the geologic history. The form of the adult test has been used as the basis in most previous classifications, but this is not alone sufficient because it is only the earlier stages that give the true relationships. Even then these stages should be observed in the microspheric form, as this is retrospective, repeating in its young many of the ancestral stages. The megalospheric specimens skip many of these earlier stages, thus arriving earlier at adult development and even assuming later characters undeveloped in the microspheric form. These two forms of the same species, the microspheric, with the small initial chamber reproducing asexually, and the megalospheric, with large initial chamber producing zoospores which fuse as in sexual reproduction, have caused much confusion in earlier work.

Instead of the ten families used in recent years, Cushman employs forty-five, due to a stricter limitation resulting in more concise grouping. The number of genera recognized has also increased, but the closely defined genera will be more easily identified than the nine inclusive groups hitherto recognized, which often contain remotely related forms. The work of many writers on the group in the past twenty years has been adopted wherever possible and the author's own studies have been largely drawn upon. The development from simple undivided forms to chambered ones is followed and the chitinous and arenaceous species are recognized as primitive, as has been done by many writers in recent years. The paper is illustrated by a table and twenty-one plates of drawings showing the relationships of the families and genera.

The publication of similar outlines of classification in all branches of biology would be not only a great stimulus to the study of natural history but also a corresponding relief to the specialist burdened with nomenclatorial problems.

R. S. BASSLER

U. S. NATIONAL MUSEUM

SPECIAL ARTICLES

NOTES ON THE MECHANISM OF FERMENTATION[1]

INVESTIGATIONS in recent years have cleared up important parts of the chemical processes in which different fermentations are concerned. Without having found final explanations, Harden and Young or L. Iwanow, for instance, have proved the necessity of the presence of phosphoric salts in the case of alcoholic fermentation. On the other hand, in 1910 O. Neubauer was in a position to show, on the basis of experiments, that in a later phase of the breaking down of sugar, which is initiated by enzymes, pyruvic acid appears to be an intermediate product. However, several years earlier Magnus Levy indicated that acetaldehyde is a probable product of the disintegration of sugars. In fact, the acetaldehyde could be intercepted and fixed by the process of Connstein and Lüdecke,[2] furnishing in the following years, especially through the activities of several investigators,[3] and recently by Willaman and Letcher, significant analytical insight into the mechanism of the breaking down of carbohydrates by means of enzymes and different microorganisms.

However, none of these investigators have given an account of the processes which are doubtlessly indispensable in explaining the physico-chemical[4] mechanism which is involved. Probably assuming that the combination of the hexoses with inorganic salts, which is supposed to initiate the real decomposition of the sugar molecules, takes place outside of the cell, Paine, in the laboratory of Harden, investigated the permeability of yeast cells to hexosephosphates. These experiments have been interpreted very differently and very strangely by different workers. According to Harden, himself, "the yeast cell is at all

[1] From the Division of Agricultural Biochemistry, University of Minnesota, St. Paul, Minn. Presented before the meeting of the Minnesota Section, Society for Experimental Biology and Medicine, on December 15, 1926.

[2] German patent, No. 298593/12o (1915); German patent, No. 298594-6/12o (1916).

[3] Comp., F. F. Nord, *Die Naturw.*, 7, 685 (1919).

[4] F. F. Nord, *Chem. Rev.*, 3, 60, 76 (1926). (This paper on "Chemical Processes in Fermentations" contains a bibliography to which the reader is referred for many of the literature citations used in the present paper. There was expressed in the same paper (p. 69) the opinion that in view of the assumed relations between thyroxin and bios the reduction of carbonyl- and other compounds by means of fermenting yeast (Lintner, Lüers, Neuberg, Nord and others) could be explained by an intermittent interaction between bios and this compound. In the meantime the former formula of thyroxin and according to a private communication from Dr. Edward C. Kendall the analysis of bios were found to be in disagreement with the facts.

events partially permeable to the sodium salt." Höber draws the conclusion that the permeability to salts is small, but he regards it also as possible that the whole phenomenon may simulate superficial adsorption, and finally C. Neuberg understood from the description of the experiments that the cell is "throughout" permeable to hexose-di-phosphoric salts.

Smedley, MacLean and Hoffert[5] in 1924 expressed the opinion "that the hexosephosphate molecules are not able to pass through the wall of the yeast cell, but that glucose and phosphate molecules pass separately into the cell, and are there combined." This assertion might be regarded as an unconscious application of the proposition of Ruhland and Hoffman[6] according to which the smaller the volume of the molecules, the faster is supposed to be their penetration into plant cells. In spite of the fact that this is contradicted by the rule of Overton, the assertion possesses a certain probability.

We must remember that the almost impossible detection of hexosephosphates in fermentations by means of yeast cells is in good harmony with the abundant formation of hexosephosphates by fermentations which are free of cells. The membrane of the cell is scarcely permeable to the synthease of Iwanow. In the case of uninjured yeast cells, there is in the outer medium only a very small quantity of hexose-di-phosphate, which might partially penetrate into the cell. If we henceforth assume, especially in accordance with the considerations and experiments of Witzemann, Gurchot and others, that also the membrane of the yeast cell represents a dynamic system which might be compared to a copper-ferrocyanide membrane, and therefore can be acted upon by intermittent coagulation and peptization, then the whole process will become readily intelligible.

The externally produced hexose-di-phosphates penetrate into the interior of the cell until a suitable salt concentration is reached which brings about the coagulation of the membrane. Through the fissures of this now "crystalline" membrane, uncombined sugar—which is typically non-diffusible—can now penetrate into the cell where it will be esterified by means of the synthease there present. The alteration (not fermentation) of the hexosephosphates into the "transportation form" of the sugar which takes place isochronously, and which is again subject to the direct splitting into the compounds of the 3-carbon chain, changes the internal concentration of the salts in such a manner that a repeptization takes place, the influx of the sugar ceases, and the cycle may be started again.[7]

The chief characteristic of the process would be, under these conditions, an intermittent coagulation-peptization of the membrane, as well as endeavoring to maintain a membrane equilibrium in the sense of Clowes (1916). No acceptance is expressed, herewith, of his or v. Möllendorff's (1918) opinion that the membrane is comparable to an emulsion, which, of course, would make it impossible to understand the osmotic activities of the cell.

It is probable to a high degree that the greater part of the sugars is esterified within the cells where the enzymes exerting fermentation are located and where they will be liberated. It is, therefore, very important to possess a conception of the mechanism of the admittance. In contrast to this, it is only of secondary significance as to whether the hexose-di-phosphates originate through an intermediate hexose-mono-phosphate (compare, for instance, Komatsu and Nodzu, 1924). In any case, they are disintegrated and leave behind the sugar in the transportation form, which is readily cleavable and which does not need to be re-esterified.[8] Isochronous rearrangements of intermittent processes exclude, of course, the accumulation of any intermediate products in the case of a normal method of fermentation.

The chief characteristic of the transportation form of a compound or system may be regarded as its capability either to mediate in intermittent actions, or to enable irreversible reactions to proceed, especially in cases where the use of a potentially higher energy content is involved.[9] It is not supposed to exist in a form which can be investigated successfully by means of our present tools as a chemical entity. Its capacity to promote the aforementioned types of biological reactions is probably due in the main to an electron transfer caused by the ionic antagonism within the cell. Ionic antagonism, we know, also exerts a great influence upon enzyme action and there are certain reasons for assuming that the same is also true for the influence of adsorption. The reasons why it is improbable that we deal in the latter case with "molecular compounds" in the sense of P. Pfeiffer will be presented in a later paper.

At this point of the considerations, attempts were made to ferment the readily accessible hydroxy-pyruvic aldehyde in its mono-molecular or trimeric form,

[5] It is probably through an error that M. Schoen (Monogr. de l'Institut Pasteur, No. 3, p. 128: 1926) recently ascribed this suggestion to other authors.

[6] W. Ruhland and E. Hoffman, *Arch. wiss. Bot.*, 1, p. 1, (1925).

[7] Compare G. Bredig and M. Minaeff, Festschrift Z. Hundertjf, d. Technischen Hochschule Karlsruhe, 1925.

[8] O. Meyerhof, *Die Naturw., 41,* 757 (1926).

[9] It is under these circumstances misleading when *e.g.*, the hexose-mono-phosphoric acids are recently designated to be "active" (compare O. Meyerhof, *Die Naturwissenschaften* 14, 1179 (1926)).

with the purpose of obtaining a better insight into the processes governing the decomposition of the 3-carbon chain compounds. No significant fermentability of a 2 per cent. solution could be observed by means of the American top or bottom yeasts which were at my disposal, in the presence or absence of mono-potassium phosphate, not even after digestion for several days at 34° C. This observation does not justify at present the drawing of definite conclusions regarding the behavior of this compound toward yeasts especially in comparing its behavior with the simultaneously effected control fermentation of d-glucose.[10] In any case the substances are not biological equivalents.

Under these conditions, we could be inclined to doubt[11] the view of Neubauer concerning the occurrence as an intermediate product of pyruvic acid in the course of alcoholic fermentation which requires as a first step methylglyoxal. C. Neuberg, Hildesheimer and Karczag in 1911 reinvestigated this question on a macro-chemical scale and, after an uncertain interpretation in a brilliant manner confirmed the previous statement concerning the transient existence of this acid. Fortunately it does not seem necessary to question these observations when we take into consideration that the experiments of Neubauer or the last-named authors are not depending on each other, viewed from a biological standpoint. In contradiction to this, the assertion that pyruvic acid is acted upon faster by fermentation than is sugar could not be confirmed by the exact investigations of Lebedew (1917, 1924), Hägglund and Augustson (1925) and others, all the more, as the control experiments on the fermentability of the pyruvic acid were carried out under unphysiological conditions. The authentic measurements of the absorption spectra by Henri and Fromageot, to which we referred already in 1925, show that under conditions of biochemically permissible concentrations, the acid is only present in the readily fermentable enol form. On the other hand, we know that the pyruvic acid is a very strong acid (K = 0.56) and since it is so highly dissociated, in accordance with the observations of Brenner,[12], Brooks,[13] and others, it may only enter uninjured cells or reach the place of enzymatic activity with great difficulty if at all. The connection of these observations is clear! The acid which is originated in a biochemical process, that is to say, within the cell, is present in the enol form which is readily fermentable. It will be isochronously decarboxylated with the same speed as the transportation form of the sugar is formed. In contra-distinction to this, when pyruvic acid is added to the mash itself, it is in an uncomparable degree more highly concentrated and will be fermented only in such proportion as the enol form is present and ready to undergo disintegration. This again is dependent on its ability to penetrate into the cell. We see, therefore, in conformity with earlier results first the outstanding significance of the transportation form of a compound which is indispensable to the initiation of a biochemical reaction.[14] There belong probably in this small group also some sulfur containing compounds newly described and investigated which were supposed to have a decisive rôle in reversible physiological processes and certain compounds of the bile promoting the hydrodiffusion of the cell.[15] The same importance also attaches to the "isochronic rearrangement" of this form, to which we referred recently[16] in connection with certain cases. It may, therefore, be regarded as certain that "unphysiologic" pyruvic acid is fermented slower than sugar in contra-distinction to the "biologic" acid which ferments practically with the same speed as sugar. It appears equally probable that considerations based on structural organic chemistry alone are hardly suitable to justify positive or negative conclusions which may be drawn from the macrochemical behavior of methylglyoxal, hydroxypyruvic aldehyde or related compounds concerning their behavior under biochemical conditions. Accordingly in the case of intracellular reactions there does not appear to be any logical basis for the calculation of a quotient based upon the rate of the fermentation of glucose as compared to that of pyruvic acid.

The more we increase our knowledge concerning the marvelous functions of the cell, the more we appear to be justified in explaining chemical reactions

[10] This observation is in contrast to yet unpublished results obtained with Miss Mollie G. White, when this compound is acted upon by *fusarium lini B.* In this case it was possible to show that this fungus may utilize this compound as a sole carbon source.

[11] Compare also H. v. Euler, *Samml. chem. u. chem. techn. Vortr., 28,* No. 6/7, p. 60 (1926).

[12] W. Brenner, *öfvers. Finska Vetensk.-Soc. Forhandl.,* 60, A, No. 4 (1917–1918).

[13] M. M. Brooks, Public Health Reports, No. 845 (1923).

[14] It does not seem desirable at present to complicate the conception by analyzing the highly probable influence that the transient acid must have on the interfacial tension of the membrane.

[15] Edward C. Kendall and F. F. Nord, *Journal Biol. Chem.,* 69, 295 (1926). F. F. Nord, *Die Naturwissenschaften,* 15, 356 (1927).

[16] F. F. Nord, Germ. Patent No. 434728/12o (1924); F. F. Nord, *Beitr. z. Physiologie,* 2, 301 (1924); C. Endoh, Rec. trav. chim. 44, 866 (1925).

on the generalization of a concept of transportation forms in contra-distinction to forms of a compound which can only be described by formulas represented in the usual manner of structural chemistry. It would also be necessary, before we can wholly explain the reactivity of the transportation form as contrasted to the ordinary form in its relation to the various variables, to know the arrangement of the electrons within the compound and the rôle which the electrical forces[17] play in the activity of the transportation form.

It is intended to report later in greater detail the experiments which are now in progress.

F. F. NORD

UNIVERSITY FARM,
ST. PAUL, MINNESOTA
November 30, 1926

PROTEUS HENRICENSIS NOV. SPEC.

A MICROORGANISM believed not to have been previously described has recently been isolated from putrefying material. The characteristics of this bacillus are such that it may be placed in the classification of Castellani and Chalmers, but not in the classification of Bergey, *et al.*

The genus Proteus Hauser[1] is defined as "highly pleomorphic rods." Filamentous and curved rods are common as involution forms. Gram-negative. Actively motile, possessing peritrichous flagella. Produce characteristic amoeboid colonies on moist media and decompose proteins. Ferment dextrose and sucrose but not lactose. Do not produce acetyl-methyl-carbinol.

The tribe Proteae Castellani and Chalmers, 1918,[2] is defined as "Bacillaceae growing well on ordinary laboratory media, not forming endospores, aerobic, without fluorescence or pigmentation, but liquefying gelatin." The tribe may be divided into genera as follows:

(A) Rapid gelatin liquefaction; do not ferment lactose; mostly Gram positive—Proteus.

(B) Slow gelatin liquefaction; ferment lactose; Gram negative—Cloaca.

The isolated microorganism has the following characteristics:

Rods: 0.5 to 0.7 by 1.0 to 3.0 microns, occurring singly and in pairs. Actively motile. Gram-negative. No spores.

Aerobic and facultative anaerobic.

Gelatin colonies: Irregular, spreading, rapidly liquefying.

Gelatin stab: Rapid, stratiform liquefaction.

Agar colonies: Opaque, gray, spreading.

Agar slant: Thin, bluish-gray, spreading.

Broth: Great turbidity, with thin, bluish pellicle.

Milk: Slightly acid, becoming markedly alkaline in forty-eight hours. Quick peptonization.

Indol formation abundant.

Acetyl-methyl-carbinol not formed.

Nitrates not reduced.

H_2S formed. Lead acetate turned brown.

Acid and gas in dextrose, xylose, trehalose and galactose.

Acid in glycerol.

No acid or gas in lactose, sucrose, mannitol, dulcitol, raffinose, levulose, arabinose, inositol, maltose, dextrin, salicin or sorbitol.

Not pathogenic for guinea pigs or rabbits.

This organism appears to be closely related to Proteus diffluens Castellani, 1915. It differs from diffluens in that it peptonizes milk, produces indol and does not liquefy coagulated blood serum. No information is at hand as to the action of P. diffluens on xylose and trehalose.

The name Proteus henricensis is suggested.

FREDERICK W. SHAW

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THE RELATION OF TEMPERATURE TO HYDROGEN-ION CONCENTRATION OF BUFFER SOLUTIONS

THE influence of temperature on optimum hydrogen-ion concentration for diastatic activity of malt has been discussed by Olsen and Fine.[1] The experimental evidence submitted showed that with "water suspensions of a mixture of wheat and malted barley flours . . . containing different amounts of dilute acid and alkali [HCl and NaOH were used] . . . the optimum pH changes from about 4.3 at 25° C. to beyond 6.0 at 69° C." These authors "suggested that this change is due to the increased activity of the hydrogen-ions present and that these apparently different pH measurements would represent approximately equal hydrogen-ion activities if measured at the temperature of the reaction."

Similar observations have been made for other enzymes. More than thirty-five years ago O'Sullivan and Tompson[2] observed for invertase that "the most

[17] Compare J. N. Mukherjee und B. N. Ghosh, *J. Ind. Chem. Soc. 1*, 213 (1924).

[1] Bergey, *et al.*, "Manual of Determinative Bacteriology," 1923, page 209.

[2] Castellani and Chalmers, "Manual of Tropical Medicine," third edition, 1919, page 943.

[1] Olsen, Aksel G., and Morris S. Fine. *Cereal Chem.*, Vol. I (1924), pp. 215–221.

[2] O'Sullivan, C., and F. W. Tompson. *Jour. Chem. Soc.*, Vol. 57 (1890), 834–931.

favorable amount of acid . . . decreases with rise in temperature," and Compton[3] has pointed out that the optimum temperature for maltase "is dependent on the H^+ concentration of the medium."

Recently Lüers and Nishimura[4] have reported observations on the basis of which they conclude that Olsen and Fine were in error. These authors used a highly active amylase preparation and soluble starch in strong acetic acid-acetate buffer solutions and found no change in optimum pH as the temperature was raised from 15 to 70° C.

Lüers and Nishimura in drawing their conclusions failed to take into account that different buffer solutions respond differently to changes in temperature. McIntosh and Smart[5] found the hydrogen-ion concentration of acetate buffers to remain constant between room temperature and 70° C., and Walbum[6] later reported extensive measurements on a number of buffers. Some of these were found not to change in hydrogen-ion concentration as the temperature was raised from 10–70° C., while certain others changed markedly. The following figures are quoted from Walbum:

Buffer	20° C. pH	70° C. pH	Difference pH
Borate	9.23	8.86	−0.37
Citrate	4.96	5.14	+0.18
Glycin-NaOH	8.53	7.48	−1.05

Recent measurements by Hoffman and Gortner[7] have shown that the pH of dilute solutions of hydrochloric acid and sodium hydroxide also respond to changes in temperature.

Inasmuch as Lüers and Nishimura were making their determinations with acetate buffer mixtures which, according to McIntosh and Smart, do not change with change in temperature, their results not only harmonize with those of Olsen and Fine but tend to corroborate the suggestion that the observed differences were due to changes in the activity of the hydrogen-ions. The different results obtained in these two cases emphasize the importance of proper selection of buffer solution where the reactions occur at temperatures other than that at which the acidity is measured.

AKSEL G. OLSEN

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[3] Compton, A. Proc. Royal Soc., Vol. 88B (1915), 408–417.

[4] Lüers, H., and S. Nishimura. *Woch. f. Brauerei*, Vol. XLIII (1926), pp. 415–416.

[5] McIntosh, J., and W. A. M. Smart. *The Brit. J. Expt. Pathology*, Vol. I, 1920) 9–30.

[6] Walbum, L. E. *Biochem. Zeitschrift*. Vol. 107 (1920), 219–228.

[7] Hoffman, Walter F., and R. A. Gortner. Colloid Symposium Monograph, Vol. II (1925), 262–269.

THE NATIONAL ACADEMY OF SCIENCES

(Continued from page 454)

Thermionic emission and the "universal constant" A: EDWIN H. HALL. Richardson, in his "Emission of Electricity from Hot Bodies" (1916), has given three derivations of the equation $I = AT^2\varepsilon \frac{bo}{\tau}$. The first of these, beginning on page 28 and ending on page 33, has been much criticized. The third, running from page 35 to 39, follows the quantum theory and reaches a result, as to the value of A, not very different from that recently found by Dushman in a similar way. The second derivation, given on a single page, 33 to 34, is admirably simple and direct, but Richardson felt obliged to give it up, because of a misgiving as to assigning thermal energy to the free electrons within a metal, though this conception of their condition is a familiar and natural one. The purpose of the present paper is to show that such a misgiving lacks justification, and to restore, with some modifications, suggested by the dual theory of electric conduction, Richardson's "classical kinetic theory" of thermionic emission.

The minimum values of positive quadratic forms: H. F. BLICHFELDT, Stanford University. Having given a positive definite quadratic form in n variables, the important question as to the least numerical value of this form, expressed as a function of n and the determinant D of the form, the variables being allowed to take on only integral values (not all zero), has received a good deal of attention. The minimum in question is $|gD|1/n$, where g is a function of n only. Superior limits to g were given by Hermite, Korkine and Zolotareff, Minkowski and the author. Exact limits are known for $n = 2, 3, 4, 5$, to be $4/3, 2, 4, 8$, respectively. In the present communication the author states that the exact limits for $n = 6, 7, 8$ are $64/3, 64, 128$, respectively.

Pressures in discharge tubes: W. H. CREW and E. O. HULBERT, Naval Research Laboratory. The increase in the pressure of the gas in a discharge tube due to the discharge has been measured for those pressures normally used in discharge tubes, from about 0.1 to 30 mm of mercury, for helium, hydrogen, oxygen, nitrogen, air, carbon monoxide and carbon dioxide. The pressure increase is regarded as due to two chief causes, one, the increase in temperature of the gas, and the other, the dissociation of the molecules of the gas into atoms or less complex molecules. Therefore, from the observed pressure increments, the temperatures and the amounts of dissociation of the gas in the discharge have been determined. A long slim discharge tube, 300 cm in length and 9 mm in internal diameter, and a large tube, 80 cm in length and 34 mm in internal diameter, were used in turn. The pressures below 1 mm of mercury were measured by a striation gauge. This consisted of a second discharge tube (joined to the main tube) excited by direct current calibrated so that the shift of the striations of the positive column with pressure was known. The pressures from 3 to 30 mm of mercury were measured by an oil manometer.

Current distribution in supra conductors: FRANCIS B. SILSBEE, Bureau of Standards. Some very clever experiments on the resistance of a tube of tin, when subjected to the magnetic field of currents both in the tube and also in a wire coaxial with it, have been described by Kamerlingh Onnes and Tuyn (Journal Franklin Institute, vol. 201, page 379, 1926). In the present paper the magnetic field distribution to be expected in such a system of conductors is analyzed in detail on the basis of a number of simplifying assumptions and the resulting potential gradient in the tube found to agree fairly well with the observed values. It therefore appears that the phenomena can be accounted for quantitatively by the assumption of a critical magnetic field and do not require the introduction of the concept of "critical current."

Heats of condensation of positive ions and the mechanism of the mercury arc: K. T. COMPTON and C. C. VAN VOORHIS, Princeton University. The two most suggestive lines of approach to the problem of accounting for the current at the cathode of a mercury arc are based on considerations of space charge and of thermal equilibrium. In this paper we wish to point out the significance of some recent work by Guntherschultze on evaporation and conduction heat losses from a cathode and by ourselves on heats of condensation of electrons and positive ions. These latter are important factors in the "energy balance" at the cathode, since the cathode is cooled by the emission of electrons from it and heated by the neutralization of positive ions at its surface. In order to measure these heats of condensation, we immersed a metal sphere in the intensely ionized atmosphere of an arc (in A, N_2 or H_2 gas) by means of three fine wires, two of which formed a thermojunction to measure the temperature of the sphere, while the third carried the current of electrons or ions flowing to it. We were thus enabled to measure the heating effect produced when either an electron or a positive ion gave up its electric charge to the sphere. For electrons the results were in good agreement with those of other observers by other methods. For positive ions our results are the first experimental determinations which have been made. They indicate that neutralization of positive electricity at the surface of a metal is accompanied by radiation of energy. Finally we used these values to interpret the phenomena at the cathode of a mercury arc. By equating all sources of energy input to all sources of energy output, two conclusions of great importance in the theory of the mercury arc are drawn: (1) electrons are pulled out of the cathode by the strong electric forces due to the cloud of positive ions near its surface; (2) mercury lost by the cathode is not all evaporated, but much of it escapes in a spray, as if mechanically extracted.

Magnetic hydrogen atoms and non-magnetic hydrogen molecules: WILLIAM ALBERT NOYES, University of Illinois. Ten years ago the author suggested that two atoms may be held together by an electron rotating about two positive nuclei. Similar suggestions were made, quite independently of each other, by Sidgwick and Knorr, in 1923. Paulus and Grimm and Somerfeld have, more recently, favored this hypothesis, and Glockler has given it some experimental support by a study of the ionization potential of methane. Quite recently, Phipps and Taylor, by a very ingenious modification of the methods of Gerlach and of Kunz, Taylor and Rodebush, have demonstrated that isolated hydrogen atoms are magnetic while hydrogen molecules are not. These facts may be explained very simply by supposing that in the hydrogen molecule the two electrons rotate in opposite directions in parallel planes with the two nuclei located between these planes. An extension of these principles might possibly explain the formation of helium from hydrogen. It is fully appreciated that the suggestion is very hypothetical and can become of permanent value only in case some one finds a method of subjecting it to a rigorous mathematical analysis and it should be found to be in accord with all the experimental facts by which it may be tested. The successes which have attended the development of Dalton's picture of the atom and the pictures of the structure of molecules proposed by Couper and Kekulé, give us some reason to hope that other pictures may be of service.

Relation of the octet of electrons to ionization: WILLIAM ALBERT NOYES, University of Illinois. In accordance with the theory of electronic structures proposed by G. N. Lewis, simple ions consist of an atom with the exterior octet shell characteristic of the atoms of the noble gases but differing from those atoms because the positive charge of the nucleus is greater or less than the number of electrons in the shell by one or more units. Complex ions have a central atom with a similar structure. As atoms of the noble gases are unable to combine with other atoms because they can not share electrons with them, it is suggested that the similar electronic structure of ions and the repulsion between the outer electrons of the shells of two ions when they approach each other may be one reason why the ions remain apart in solutions and why they have some of the properties of independent molecules.

Exhibit of research results in the Grand Canyon: JOHN C. MERRIAM.

Footprints of unknown vertebrate animals in the Carboniferous and Permian of the Grand Canyon, Arizona: CHARLES W. GILMORE, U. S. National Museum. This paper describes the results obtained from two trips to the Grand Canyon of the Colorado, undertaken for the dual purpose of securing collections of fossil tracks for the U. S. National Museum, and at the same time, to prepare an exhibit of the tracks *in situ* for the National Park Service. Both of these projects were successfully carried out, a collection of slabs of footprints some 4,400 pounds in weight were secured for the National collections and a track covered area several hundred

square feet in extent was uncovered by the side of the Hermit Trail, thus forming a permanent exhibit of the tracks as they occur in nature. It was found that tracks occur in considerable abundance in three distinct and successive formations. These evidences of past life ranging through 800 feet of strata, confined to horizons that roughly stated lie as follows: Coconino, 900 to 1,030 feet; Hermit, 1,350 to 1,400 feet; and Supai, 1,760 to 1,800 feet below the top of the canyon wall. In the perfection of their preservation and variety of kinds there are but few localities known that outrank this one. In all 24 genera and 33 species of fossil tracks have now been recognized, distributed as follows: Coconino, 15 genera and 22 species; Hermit, 6 genera and 8 species, and Supai, 3 genera and 3 species.

The age of the Hermit shale in the Grand Canyon, Arizona: DAVID WHITE.

Fauna and flora of a new Pleistocene asphalt deposit near Santa Barbara: CHESTER STOCK and RALPH W. CHANEY (introduced by John C. Merriam).

Significance of geological range, or life period of animal species. John C. MERRIAM.

The architectural evolution of Pueblo Bonito: NEIL M. JUDD, U. S. National Museum. Pueblo Bonito, a prehistoric Indian village situated in Chaco Canyon, northwestern New Mexico, was abandoned approximately one thousand years ago. This, at least, is the conclusion reached by archeologists after six years of exploration for the National Geographic Society and after careful weighing of all anthropological, historical, geophysical and other available data. Pueblo Bonito is one of the largest and best preserved Pueblo villages of the southwestern United States whose abandonment is known to have occurred long prior to inauguration of the Spanish conquest in 1540. Ruins of the ancient settlement—a compact, communal building surprisingly similar to our modern apartment houses—cover more than three acres of ground. In its heyday, Pueblo Bonito stood four stories high, comprised nearly eight hundred rooms, and sheltered between twelve and fifteen hundred individuals. Its builders were farmers—agricultural folk who tilled fields of maize, beans and squash, and added to their vegetable diet such desert game as ranged within hunting distance. The Bonitians had no beasts of burden and no metal implements or ornaments excepting a few small copper bells obtained, through intertribal commerce, from Toltec or Aztec Indians of central Mexico. It was formerly supposed that Pueblo Bonito must have been erected from previously prepared plans and as a single cooperative enterprise. Explorations of the National Geographic Society, however, have disclosed definite evidence of four major periods of building activity with recurrent alterations of lesser magnitude in each major period.

Late Tertiary thrust faults in the Mojave Desert: D. F. HEWETT, U. S. Geological Survey. For many years it was assumed that most of the folds and other evidences of compressive stresses in the rocks throughout the Great Basin were due to the intrusion of the Sierra granite in early Cretaceous time. The thrust faults of southeastern Nevada, first recognized in 1919, were so considered. Work in the Goodsprings area in 1922 threw some doubt on this conclusion and work further south in 1924 seemed to confirm the doubt. As they were known to be pre-Miocene, an early Eocene age was assigned to the thrust faults and associated granites. Work in 1926 along the northeast border of the Mojave desert in the vicinity of the Shadow Mountains shows that there is a local zone ten miles wide and at least thirty miles long, in which early Paleozoic and Precambrian rocks, including granite gneiss, are thrust upon upper Miocene sediments. The zone appears to be continuous with the fault traced 150 miles westward through Leach Trough, which separates the Mojave desert from the rest of the Great Basin. Two periods of Tertiary thrust faulting are thus indicated. The depression of Death Valley which typifies many of the closed valleys of the region crosses this fault and is limited by still younger normal faults.

Boring for natural steam in California: ARTHUR L. DAY.

Recent volcanic activity in Japan: ARTHUR L. DAY.

Sea-level surfaces and the problem of coastal subsidence: DOUGLAS JOHNSON, Columbia University. It has previously been shown that many phenomena attributed to recent progressive coastal subsidence are due to local fluctuations in the "high tide surface" (the irregularly curved surface passing through all points reached by the crest of the tidal wave) consequent upon local changes in the form of the shore. The present paper supports the thesis that the "mean sea-level surface" is also an irregularly curved surface, and that local changes in the form of the shore may produce local variations in the elevation of mean sea-level. Such variations of mean sea-level give rise to phenomena erroneously interpreted as indications of changes in the elevation of the land; and of such phenomena those giving fictitious indications of coastal subsidence are most pronounced.

The fundamentals of isostasy: HARRY FIELDING REID, Johns Hopkins University. A consideration of all the forces acting on a point on the earth's surface, together with the fact that the earth's level surface is almost exactly an ellipsoid of revolution, shows, without any assumptions, that to all masses rising above a properly chosen ellipsoidal surface there is a complementary negative mass of matter within the ellipsoid. The condition that the complementary mass shall be equal to the exterior mass is that the ellipsoid shall contain all the matter of the earth. It should therefore be about 200 meters above the sea-level. The observations show, without hypotheses, that the greater part of the complementary mass, which has been called the compensation, lies in the neighborhood of the masses compensated.